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Commonwealth of Pennsylvania

DEPARTMENT OF FORESTRY

BULLETIN No. 15

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Reforesting Pennsylvania's Waste Land

What and How to Plant

BY

W. GARDINER CONKLIN.

In Charge of the Bureau of Silviculture and Mensuration

Issued by Direction of the Commissioner of Forestry

HARRISBURG, PA.:
WM. STANLEY RAY, STATE PRINTER.
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PENNSYLVANIA DEPARTMENT OF FORESTRY.

Robert S. Conklin,
Commissioner of Forestry.

Irvin C. Williams,
Deputy Commissioner of Forestry.

STATE FORESTRY RESERVATION COMMISSION.

Robert S. Conklin,
President.

S. B. Elliott,
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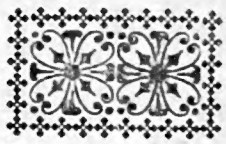
BUREAU OF SILVICULTURE AND MENSURATION.

W. Gardiner Conklin, in charge.
Raymond B. Winter, Assistant.



LETTER OF TRANSMITTAL.

Hon. Robert S. Conklin,

Commissioner of Forestry.

Dear Sir:

The many inquiries received from persons throughout the State requesting information on reforesting waste lands have prompted the preparation of this bulletin, "Reforesting Pennsylvania's Waste Land." It has been written for the purpose of advising interested persons how to reclaim their waste land, where to obtain the planting stock, the species best to plant, and how the planting should be done.

The information herein contained has been gleaned largely from data obtainable as the result of planting on Pennsylvania's State Forests. This opportunity is taken to thank the field force of foresters for supplying much of the data.

Appreciation of the assistance rendered by Prof. J. S. Illick, of the Pennsylvania State Forest Academy, who supplied the habitats of the species suggested for planting is hereby tendered.

The illustrations given are practically all from the collection belonging to the Pennsylvania Department of Forestry. Except when otherwise noted, the illustrations are from photographs taken by the author. Special mention should be made of those taken in plantations on the Jacob Nolde Estate, Berks county, by District Forester James E. McNeal.

The bulletin is presented with the hope that it will be published and distributed freely throughout the State.

Very respectfully yours,

W. GARDINER CONKLIN,

In charge of the Bureau of Silviculture and Mensuration.

Harrisburg, Pa.
November 27, 1916.

CONTENTS.

PART I.

WHAT AND HOW TO PLANT.

	Page.
Introduction,	9
Why waste lands should be reforested,	10
Classes of land in Pennsylvania which should be reforested,	10
A plantation defined,	12
Success or failure of the plantation,	12
Species to plant,	12
Purpose of the planting,	15
Light requirements of trees,	16
Age and size of planting stock to use,	16
Time to plant,	18
Care of planting stock,	18
Preparation before planting,	19
Spacing,	19
Mixture of species,	20
Method of planting,	21
Digging the hole,	21
Setting the seedling,	21
The planting crew,	21
Cost of planting,	22
Rate of growth,	23
Protection of the plantation,	27
Fire,	27
Grazing,	27
Gnawing animals,	27
Insects,	27
Fungi,	28.

PART II.

WHERE AND HOW TO OBTAIN PLANTING STOCK.

	Page.
Planting stock may be furnished by the Department of Forestry,	29
How to obtain planting stock ,	30
Advice and examination,	32
What is required of the recipient,	32
Nursery stock receipt,	33
Nursery charge,	33
Plantation report for private planting,	33
Species usually available for free distribution,	33
Points to bear in mind,	34

REFORESTING PENNSYLVANIA'S WASTE LAND.

WHAT AND HOW TO PLANT.

PART I.

Introduction.

A conservative estimate places Pennsylvania's forest area at approximately 7,500,000 acres, of which 5,000,000 acres are in a non-productive condition. The remaining 2,500,000 acres are producing timber suitable for lumber. These 7,500,000 acres of land are largely mountainous and because of their steepness, rocky condition, and lack of fertility, are not adaptable for any purpose except the production of lumber. A large proportion of the 5,000,000 acres can be made productive only by the planting of forest trees, and a systematic effort should be made by every owner of such land to plant at least a portion of his holdings each year. If this be done, Pennsylvania can produce lumber sufficient not only for its own use, but can supply millions of feet annually for use outside of the State.

Why is this land in its present barren condition? It was once covered with forests, why not now? In brief, because after the original forests were cut, the land was left to take care of itself. Forest fires started and little or no attempt was made to check them unless they endangered mature growth or rural habitations. These fires burned repeatedly over the mountains, destroying all chance of natural regeneration, leaving the lands barren and waste. This condition exists particularly throughout the coal districts and the plateau region in the northern part of Pennsylvania. To the layman, the land appears entirely worthless, but not so to the forester. He sees the possibilities of the land when planted to forest trees. He also sees that protection from forest fires is the first necessity.

It is estimated that, in addition to the 7,500,000 acres of forest land, there are in Pennsylvania 2,000,000 acres of waste farm land. This land was cleared but now proves worthless for agriculture. A portion of it, no doubt, is used for grazing purposes, but undoubtedly with little success. Such land should be planted with forest trees.

WHY WASTE LANDS SHOULD BE REFORESTED.

Two of the most substantial reasons for reforesting are the need for protection of water sheds. These in themselves are sufficient but many others may be cited. The essential economic aspects, lumber production and water shed protection, are to be considered here.

Taxes are being paid annually, or supposedly so, on five million acres of land in the State from which the owners are receiving little or no return. The land represents idle capital—money,—producing no interest on the investment. Every instance of this sort means a direct financial loss to the owner.

In 1860, Pennsylvania produced more lumber than any other State in the Union. In 1880, she stood second with an annual cut of 1,733,844,000 board feet. In 1915, the reported cut was 657,-853,000 board feet and her standing as a lumber producing State was twentieth. Lumbering in past years was done without apparent thought for the future. Forest fires followed lumbering, completing the destruction of our forests. Now, nearly one-fifth of the State, so far as surface value is concerned, may be classed as unproductive. The only way to reclaim this land is by artificial reforestation, i. e., planting.

Protection of water sheds is a matter of most vital interest to every resident of the State. A continuous supply of pure water is essential to health and prosperity. Where better can pure water be had than direct from forested areas? It is a fact undeniable that a more uniform flow of water is had from land covered with dense forests than from agricultural lands or waste areas. The humus of the forest floor is a sponge. It holds water, allows it to run off gradually, and thus regulates the supply. Whenever possible, watersheds, particularly the source of drinking water, should be in forest; or, if devoid of tree growth, they should be reforested by planting. Many water companies own or control a portion of the lands which are the source of their water supply. Forests on these lands would not only assure a purer and more uniform flow of water, but would eventually mean an additional source of revenue to the companies. Under proper forest management, timber may be removed without noticeable injury to the protective covering of the water shed.

CLASSES OF LAND IN PENNSYLVANIA WHICH SHOULD BE REFORESTED.

Practically all types of land in Pennsylvania which should be planted to forest trees may be placed in one of the classes described below. Much of the land given in this classification is now practically barren of commercially valuable species and must be planted to make it productive.

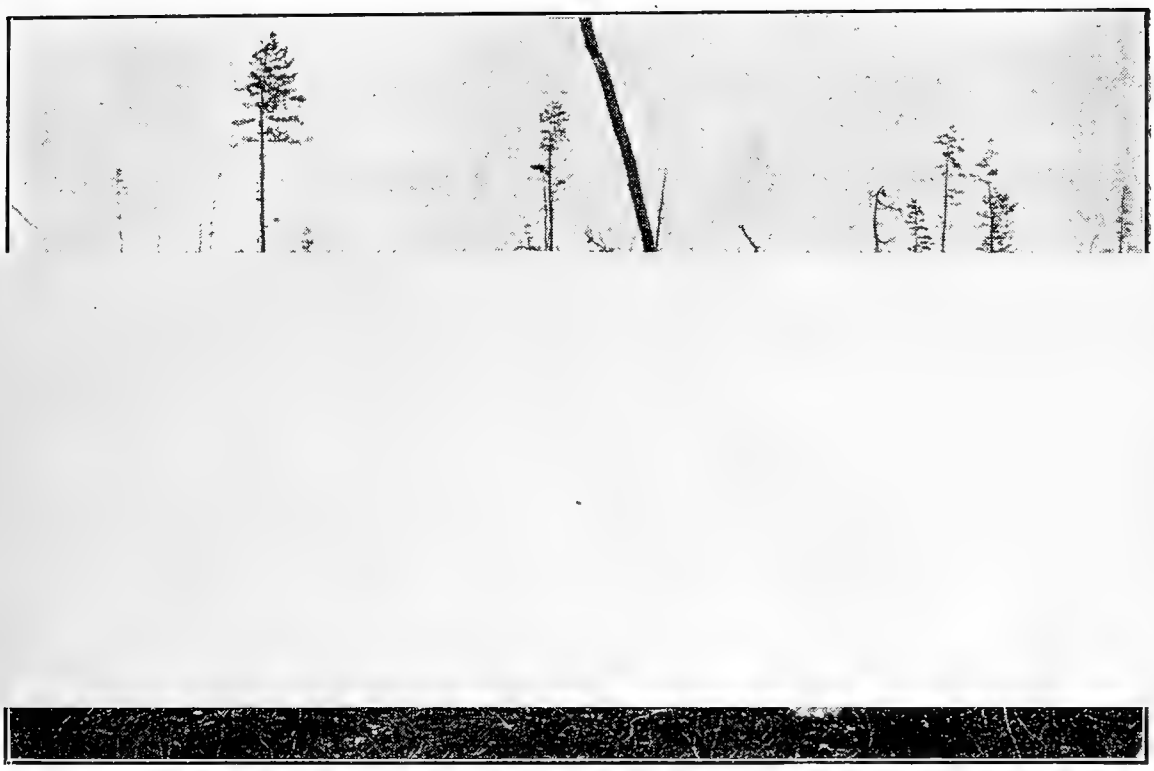


Photo by C. S. Bradford.

Fig. 1. WASTE AREA.

Destructive lumbering followed by forest fires have laid this land waste. It should be protected from fires and planted with trees.

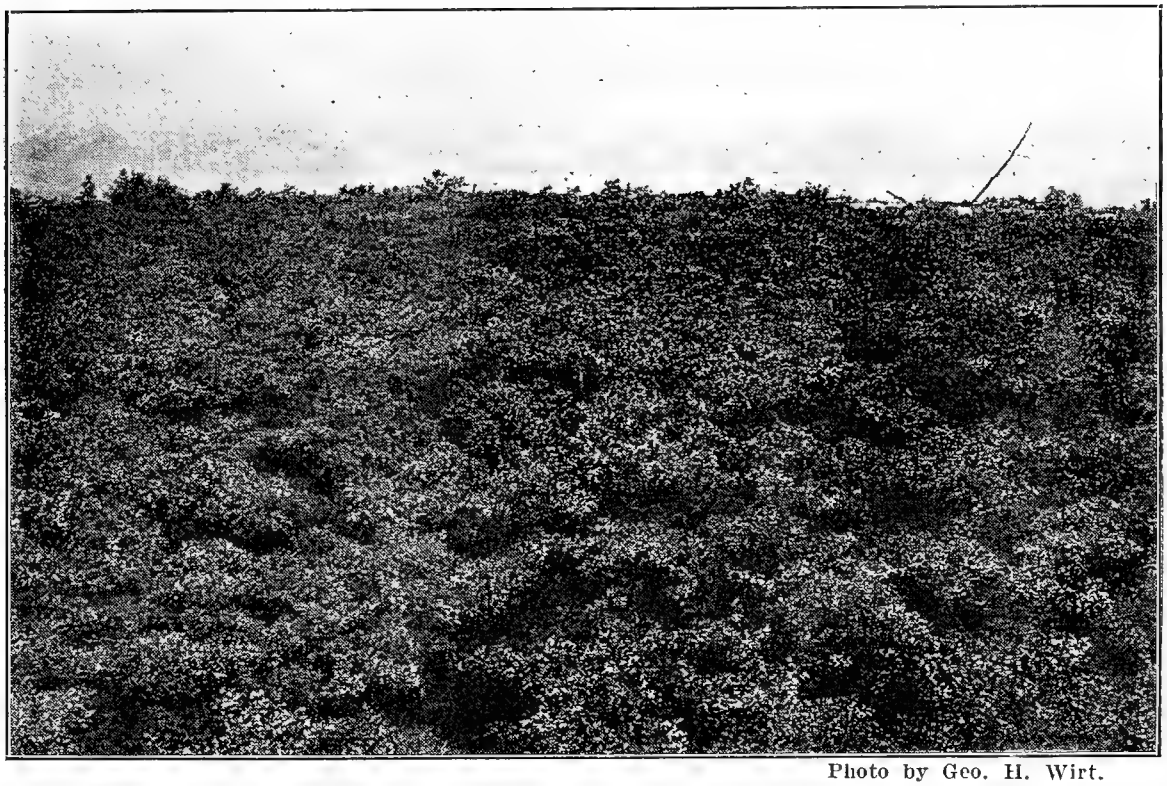


Photo by Geo. H. Wirt.

Fig. 2. SCRUB OAK BARREN.

Thousands of acres of this class of land are found in Pennsylvania. The scrub oak should be replaced by planting valuable species.

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ERRATA.

First and second lines, page 10, should read, "Two of the most substantial reasons for reforesting are the need of producing lumber for future use, and the need for protection of water sheds."

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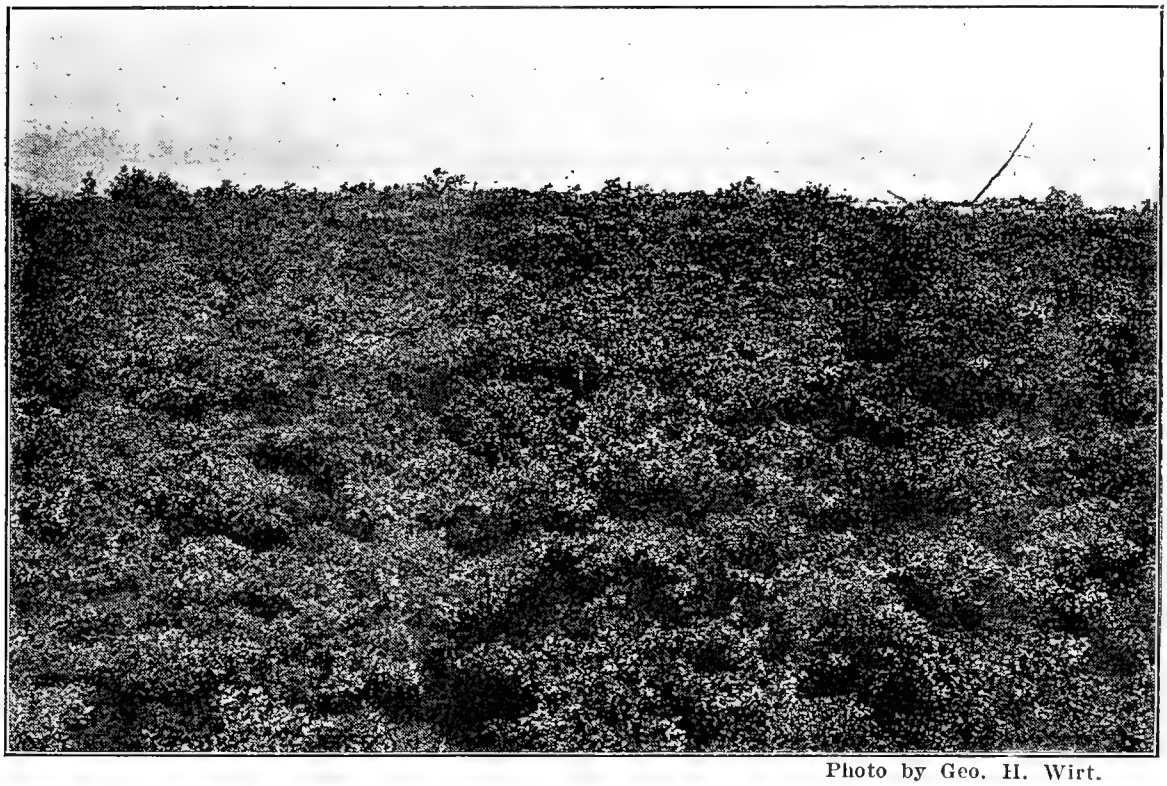

Photo by Geo. H. Wirt.

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Thousands of acres of this class of land are found in Pennsylvania. The scrub oak should be replaced by planting valuable species.

Photo by Geo. H. Wirt.

Fig. 3. AREA OF BRACKEN AND WEEDS.

Now waste land. It once produced the best of timber. This land should be planted.

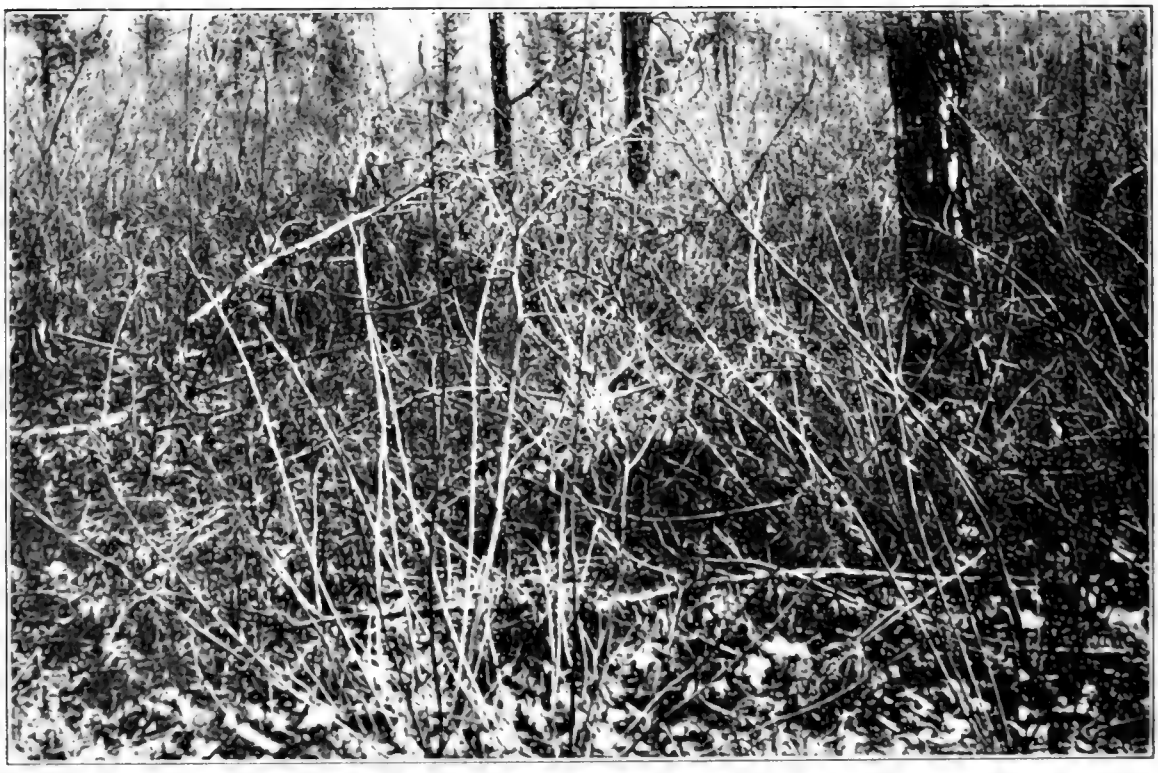


Fig. 4. BRUSH LAND.

Reproducing nothing of value. The brush was subsequently burned and the area planted with white pine, Norway spruce, and Scotch pine.

Class I. Areas originally farmed but which have proved unsuitable for agricultural purposes. Land in this class may be found in all parts of Pennsylvania, especially on steep slopes.

Class II. Farm woodlots. It frequently occurs that the woodlot contains few species of commercial value, due to improper management or other cause. These woodlots should be underplanted or reenforced with valuable species. Practically every farm has its woodlot, and many of them are in immediate need of restocking with useful species.

Class III. Second growth hardwood lands. These are producing some few trees of value but of inferior quality due to decay following injury by fires. Lands of this type are common throughout Pennsylvania and comprise a considerable part of the mountainous region in the central and southwestern portion. Much of this class of land should be underplanted with commercially valuable trees. Defective trees ought to be removed either before planting, or after the planted trees have reached a height of ten to twenty feet. They should not be cut at the expense of injury to the planted trees.

Class IV. Water sheds, particularly the source of water used for drinking purposes. Land in this class may also be included in any of the other classes.

Class V. Areas covered with bracken and sweet fern. Land of this sort is found throughout the State but more particularly on the plateau regions of the north central and northern portions. It frequently is land which originally produced the best of white pine timber, but was left to devastating fires after lumbering and is now entirely or in part, devoid of trees. Such land can be planted and made to produce lumber as good or even better than that cut from the former virgin forest. Considerable areas of this type comprising State Forests have been planted successfully by the Department of Forestry. See Figure 3.

Class VI. Coal and oil lands from which the forests have been cut and the surface severely burned. Land of this type is found in the central eastern portion of the State, and throughout the western part beyond the Allegheny Mountains.

Class VII. Scrub oak barrens, land which formerly produced valuable coniferous and hardwood timber but which was left unprotected after the timber was cut. Scrub oak, a non-commercial species and a prolific sprouter, the roots of which are seldom killed by fire, is light demanding and quickly dies out when over-topped. Planting this land is difficult and expensive, and the planted trees grow slowly. However, when they once shade the scrub oak, it quickly dies out. This type of land is found in all parts of the State but more especially east of the Allegheny Mountains.

A PLANTATION DEFINED.

The term plantation, as used in forestry, considers the planting of an aggregation of young trees with the idea of forming a forest or woods. As used by the Department of Forestry, the term implies the contiguous area planted in any one year. In case an immediately adjacent area is planted in other years, that planting is regarded as a separate plantation. This meaning of the term has been adopted simply as an aid in systematizing planting records. A broader use of the word would allow the plantings of separate years to be conjoined as one plantation.

A plantation may be made either where no trees exist or where they do exist but not in sufficient number to produce the maximum of wood volume per unit of area. The latter is termed a "reenforcement of natural growth" and the operation that of "under planting."

Reenforcing is frequently necessary or advisable in established plantations. Not all the trees planted live and if the area planted is to be fully stocked, filling in should be done in the fail spots.

SUCCESS OR FAILURE OF THE PLANTATION.

The success or failure of a plantation depends on a great many factors, most of which may be influenced or controlled by human endeavor. Among the more important factors which influence success and which must be carefully considered before planting, are soil, climate, and existing growth; also topography, including altitude, angle of slope, and aspect. The species to be planted should be such as are adaptable to the site, that is, to the soil, topography, etc. Adverse conditions of the planting site require more careful selection of the planting stock, both in regard to species and quality of stock, and the degree of care in the planting.

To the layman the various factors influencing success are not apparent or understood, and persons are cautioned not to engage in extensive planting operations without receiving advice and suggestions from a competent authority, such as a trained forester. A forester should make a very careful examination of the planting site and consult the owner on the purpose of the planting before designating species to plant. Upon his judgment depends largely the success or failure of the venture.

SPECIES TO PLANT.

Any species of tree which grows naturally in a locality may be used, but it is best to choose such species as will produce the most valuable wood, depending, of course, on the purpose for which the plantation is made. It should be remembered that most of our hardwood or broad-leaved trees (oaks, chestnut, maples, etc.) are better capable of being reproduced naturally than are the conifers

or softwood species (pines, spruce, larch, hemlock, etc.). In consequence, by far the largest proportion of artificial reforesting is done with evergreen species. Out of a total of 22,045,311 trees planted on Pennsylvania State Forests to date, 20,828,775 were conifers.

Different species require different soil and soil moisture conditions to produce normal rate of growth and these factors must be considered in choosing the species to be planted. Among the more valuable trees to plant, and the conditions in which they may be expected to succeed best are:

CONIFERS OR SOFTWOOD TREES.*

White pine (Pinus Strobus).—Prefers a fertile, moist, well-drained soil, but will grow well on dry sandy soils and gravelly slopes. Common on banks of streams, river flats, in hollows and ravines, but rarely found in swamps. Any habitat in its natural range will be favorable to its development except swamps and ridges exposed to severe winds.

Pitch pine (Pinus rigida).—Common on dry burned-over areas, sterile plains, gravelly slopes, rocky cliffs, and sometimes found in swamps. In the glaciated area it is common on rocky glacial soil.

Red pine (Pinus resinosa).—Usually found on dry gravelly ridges, mountain tops, and dry sandy plains. Rare on flat lands with wet clay soil.

Short leaf pine (Pinus echinata).—Common on poor, sandy, or clayey soil. It is a tree of the plains and foothills. Reaches west of the Mississippi. In the east it is usually mixed with hardwoods.

Scotch pine (Pinus sylvestris).—This species is indifferent to soil requirements, water, heat of summer, and cold of winter. It will grow on all classes of soil, even dry, sterile sand. The rate of growth depends more on the physical structure than the chemical composition of the soil. It prefers deep well drained sandy loam. It is very intolerant of shade.

Norway spruce (Picea Abies).—In Europe it grows in valleys and upon the mountain slopes. It prefers rather rich moist soils, in this respect somewhat resembling the white pine. It cannot endure very dry, very sterile, or extremely rich vegetable soil. It is rather tolerant of shade and somewhat susceptible to late frosts.

European larch (Larix decidua).—Not native to America but planted here with every indication of success. Thrives on well-drained, deep, and moderately fertile and loose soil. Does not thrive in wet situations nor in pure sands. It is decidedly intolerant of shade. Found chiefly in the Alps and Carpathians up to about 8,000 feet.

Japanese larch (Larix leptolepis).—This tree is native to the central part of Japan, chiefly at high altitudes upon soil of volcanic origin. Makes its best growth in soil rich in lime and in cool to

*Habitats supplied by Prof. J. S. Illick of the Pennsylvania State Forest Academy.

cold climates. In warm climates the tree becomes branchy, the wood coarse-grained and the growth rings wide. Dr. Mays states that it will grow wherever Norway spruce thrives. Grows rapidly in youth. Falls behind the European larch about the 20th year. A specimen near Munich attained a height of 45 feet and a diameter (D. B. H.) of 11 inches in 22 years. The planting of this species is still in the experimental stage and not to be too highly recommended.

Bull pine (Pinus ponderosa).—Like Scotch and Jack pine, this tree is not particular to soil, but will reach good development even on arid soils and dry mountain slopes. It is one of the species best suited to dry, sandy and gravelly soils.

Jack pine (Pinus Banksiana).—Like Scotch pine in its habitat. Thrives on sandy, sterile soil.

HARDWOODS, OR BROAD-LEAVED TREES.*

White oak (Quercus alba).—It is tolerant of many soils, growing on sandy plains, gravelly ridges, rich uplands, and moist bottom lands. It reaches its best development in rich moist soil.

Red oak (Quercus rubra).—Prefers porous sandy or gravelly clay soil. It will not grow in wet soils and is also intolerant of shade, except when young.

Honey locust (Gleditsia triacanthos).—It develops best in rich soil along moist river bottoms but will grow in any fertile soil which is not too wet. It demands plenty of light.

Black locust (Robinia Pseudo-Acacia).—Grows vigorously on moist fertile soil, especially on rich bottom lands and along mountain streams. Also grows on rather rocky and sterile mountain slopes. Frequent on abandoned charcoal hearths and mud-dams found near ore mines.

Sugar maple (Acer saccharum).—It flourishes best on well drained rich soil, but will thrive even when the soil is not rich. It is common on low ridges at the base of the mountains, and along slopes. It reaches its best development in central New England, New York, northern Pennsylvania, and the Lake States.

Black walnut (Juglans nigra).—Prefers rich moist soil. Requires plenty of light and deep soil since it is evidently tap-rooted.

Black cherry (Prunus serotina).—Thrives best on rich alluvial soil and fertile slopes. It will grow on dry and often rather sterile slopes. On account of its long tap-root it requires loose deep soil.

Tulip poplar (Liriodendron Tulipifera).—It prefers deep, rather rich, and moist soil. Common along streams, on islands, upon semi-swampy areas, and at the base of mountain slopes. Sometimes found on the top of mountains especially where small streams and springs are prevalent. Usually occurs as scattered individuals mixed with other hardwoods and sometimes white pine and hemlock. Does not thrive on limestone soil. Common along mountain streams until they enter limestone valleys, then disappears.

*Habitats by Prof. J. S. Illick of the Pennsylvania State Forest Academy.

White ash (Fraxinus americana).—Prefers fertile, moist soils; very common in rich, moist woods and along streams, lakes, and other bodies of water. Occasionally found on rather dry hillsides.

Basswood (Tilia americana).—Rarely grows in pure stands, but usually mixed with other hardwoods. Prefers rich soils in bottom lands. It can endure considerable shade. It suffers little from windfall but occasionally from windbreak upon exposed situations.

Sycamore (Platanus occidentalis).—Prefers moist, fertile soil, but will grow in rather dry soil. Best development in the moist valleys of the Ohio and Mississippi rivers. It may be grown from cuttings or from seed.

Shell-bark history (Carya ovata).—Prefers rich moist soil and plenty of light. Common in the valley and in moist hillside woods. Also common along streams, and on the border of swamps.

Pignut hickory (Carya glabra).—Most common on dry ridges and hillsides. Rarer in swampy situations. Commonly scattered amidst our oaks and chestnut. Prefers plenty of sunlight.

Black birch (Betula lenta).—Usually found in rich soil and on dry slopes but also common on rocky mountain slopes and tops. Common on the rocky ridges of the South Mountains in Pennsylvania.

Beech (Fagus grandifolia).—Commonly found on rich moist bottom lands, but also abundant on gravelly slopes and rich uplands. It endures dense shade and variations of temperature. Rare in the limestone valleys.

Cucumber tree (Magnolia acuminata).—Uusually found in rich woods close to streams, also inhabits slopes. In West Virginia and in this State it grows well on the soils of the carboniferous formation. It is light-demanding.

PURPOSE OF THE PLANTING.

It is pre-supposed that persons desiring to plant trees have a definite object in mind. It may be water shed protection alone or only for aesthetic purposes. More often, however, the intention of the owner of the land is to produce wood for one or more of its many uses. If the object in mind is water shed protection alone, practically any species adapted to the site may be used. If for beautifying the landscape, it is usually best to plant a variety of species. But if wood production, lumber, etc., is the main object in mind, the species used must be such as are both adapted to the site and to the use to which the wood is to be put. The following table gives a list of species suitable for different uses. The table includes only those species which it is herein suggested to plant.

TABLE NO. 1. USES TO WHICH THE VARIOUS WOODS MAY BE PUT.

General Lumber.	Paper Pulp.	Cooperage Stock.	Poles and Posts.
Practically all species which have any commercial value are used in different forms of rough or finished lumber.	Spruce. Pine. Larch. Yellow poplar. Carolina poplar. Beech. Hemlock. Maple. Basswood. Douglas fir. Bull pine. Jack pine. Sycamore.	Beech. Chestnut. Maple. Birch. Oak. Red gum. Ash. Elm. Yellow poplar. Basswood. Pine. Spruce. Sycamore.	Chestnut. Honey locust. Black locust. Red oak. Larch.

Mine Timbers.	Railroad Ties.	Hardwood Distillation.
Oaks. Chestnut. Black locust. Honey locust. Pitch pine. European larch. Bull pine.* Jack pine.*	White oak. Red oak. Beech. Black locust. Honey locust. Pitch pine. European larch. Bull pine.* Jack pine.*	Beech. Birch. Sugar maple. Also many other hardwoods.

*Not durable but sometimes used.

LIGHT REQUIREMENTS OF TREES.

Each species of tree has its particular requirement concerning the amount of light necessary to produce the best rate of growth. Certain species cannot survive shade and are known as intolerant or light-demanding species. Others produce satisfactory results under partial shade and are termed tolerant or shade-enduring species. In general, all the species which are advised as suitable for reforesting in Pennsylvania are light-demanding species, with the possible exception of white pine, Norway spruce, black birch, and beech. These species will endure a moderate amount of shade on good soil, particularly Norway spruce and beech.

AGE AND SIZE OF PLANTING STOCK.

The age and size of plants used depend on the type of land to be planted and the species selected. Such factors as accessibility to the planting site, distance from the nursery, and the purpose of the planting must also be considered. The rule is, the larger the seedlings, the greater the planting cost.

Adverse planting conditions require a larger and stronger plant than where conditions are more favorable to success. In order that the planting may be done at the lowest possible cost, the smallest

SEEDLINGS USED IN REFORESTING.

(Arrows point to root collars)

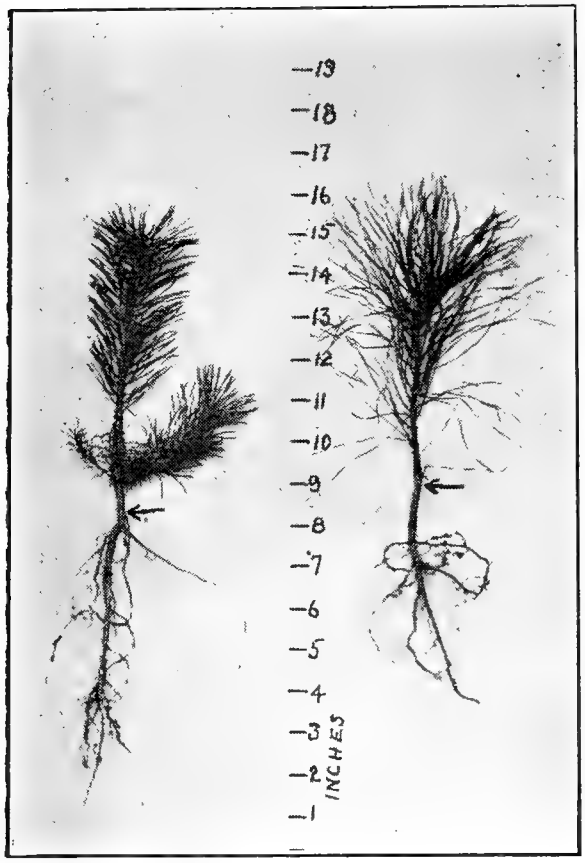


Fig. 5. Pitch pine (left) and Scotch pine (right), two years old.

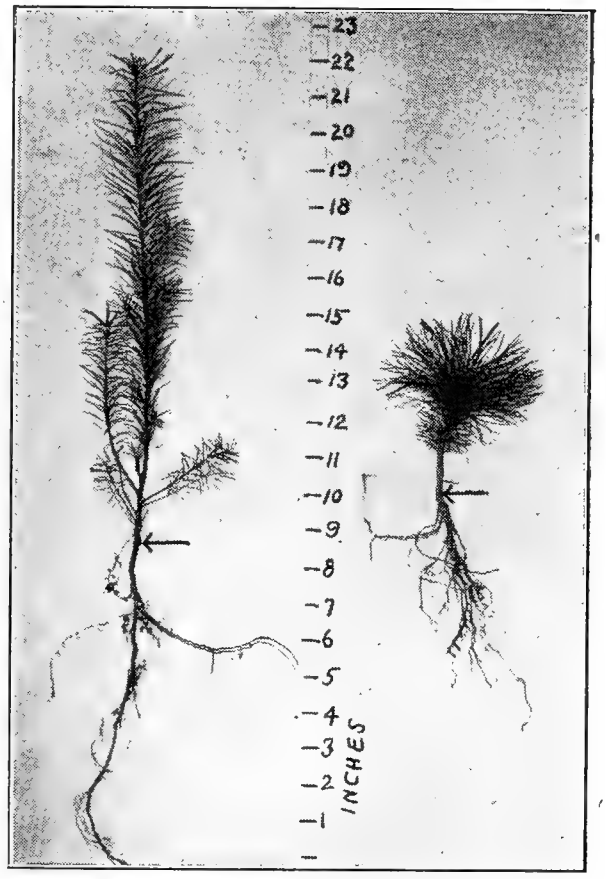


Fig. 6. Japanese larch (left) and white pine (right), two years old.

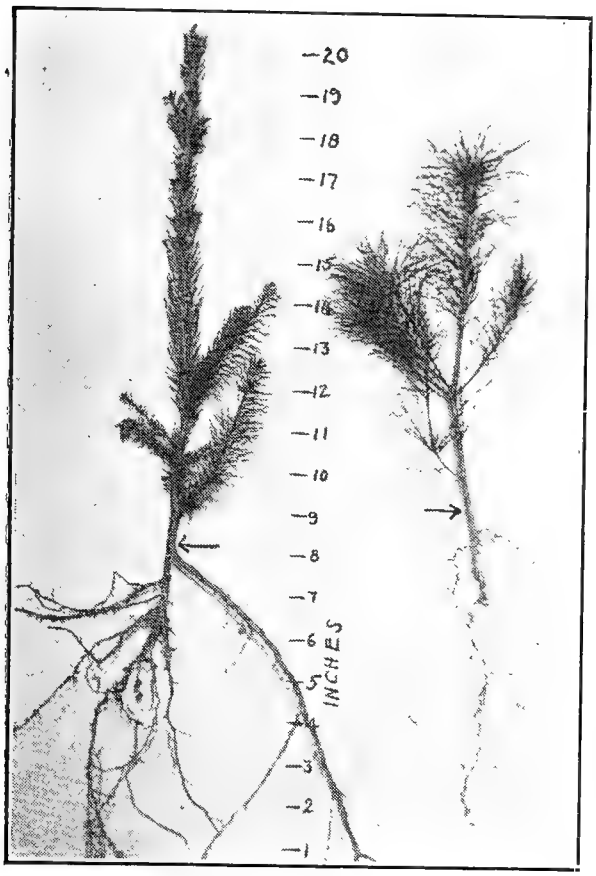


Fig. 7. Norway spruce (left) and white pine (right), three years old.

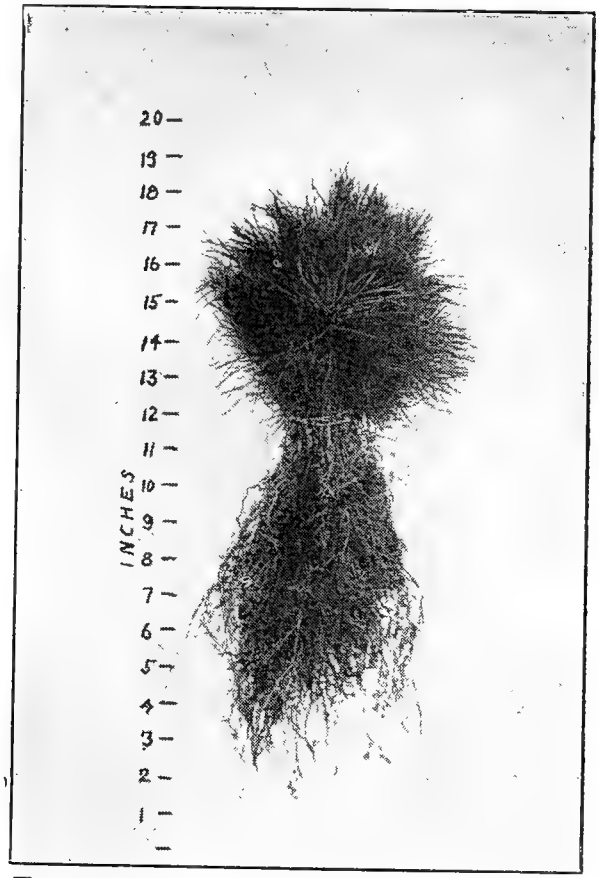


Fig. 8. A bunch of 50 white pine seedlings, two years old, ready for packing and shipping.

Fig. 9. CARE OF PLANTING STOCK.
25,000 seedlings "heeled in" preparatory to planting.

Photo by Geo. H. Wirt.

Fig. 10. PREPARATION BEFORE PLANTING.
This area was cleared of brush, then planted. It is too expensive to be practical.

seedlings suitable for any particular site should be selected. The layman usually desires quick results and in consequence asks for large plants. Economically considered, this is poor policy because of the increased cost of planting. Also, where too large seedlings are used, the chance of obtaining a good percentage of establishment is lessened unless unusual care is used in the planting.

Broad-leaved species may usually be planted when one year old. If left more than one year in the nursery, providing proper development is obtained, long tap roots result and require pruning. Even one year old broad-leaved species may have to be pruned. This increases the cost of the plantation and reduces the chance of obtaining good establishment. One year old broad-leaved species range in height from 6 to 12 inches above the collar, and the roots frequently are still longer. In 1916, a total of 153,010 hardwood seedlings were planted on State Forests and of this number only 12,000 were other than one year old. These were white ash which had been injured by frost while in the nursery and not of sufficient size at one year to warrant placing them in permanent plantation.

Coniferous plants used for reforesting on State Forests vary in height from 4 to 12 inches and are two or three years old. By far the largest percentage of seedlings used in planting on State Forests have been two year olds. In 1916, a total of 5,339,010 conifers were planted, and of this number 5,255,420 were two year stock.

It is seldom advisable to plant other than two year old pitch pine, Scotch pine, or European larch. White pine two years old is generally large enough. However, if adverse soil, moisture, and shade conditions must be overcome, three year stock, particularly white pine, had better be used. In this State, experience has demonstrated that three year old Norway spruce should be used, for uniformity in size is seldom had in the nursery beds and if taken from the nursery when two years old, a large percentage of the seedlings will be undersized and too small to plant out.

Figures 5, 6, 7, and 8 are from photographs of seedlings two and three years old. Stock such as there shown is used for planting by the Department of Forestry. The scale given represents size of seedlings in inches. Arrows indicate the collar of the plant, which is the point marked by the surface of the ground.

The age of seedlings is reckoned by the number of growing seasons they have passed in the nursery beds. Occasionally seedlings are transplanted in the nursery when one or two years old and are known as transplants. Their age is given as 1-2 years, 2-1 years, etc. The first numeral indicates the number of years in seed beds and the second the number of years in transplant beds. A 1-2 transplant has passed through three growing seasons in the nursery.

TIME TO PLANT.

Reforesting may be done either in spring or fall, preferably spring. Experiments with fall planting have been made on State Forests but gave unsatisfactory results. It was found that a large proportion of the small trees were lifted out of the ground by the following spring. The cause of this was freezing and thawing of the ground before the roots could properly grip the soil. Planting in the spring should be done between the time frost is out of the ground and the time when the buds begin to shoot out the new year's growth. The season in the southern part of the State begins about the last week in March and ends about the last week in April. In the northern part of Pennsylvania the planting season is from one to three weeks later, depending upon altitude.

CARE OF PLANTING STOCK.

Planting stock from State forest nurseries is given careful attention before being shipped. The small trees are lifted from nursery beds in such manner as to do the least possible injury to the roots. This is particularly true of conifers since their roots are more susceptible to permanent injury than those of hardwoods. After lifting, they are counted and tied in bunches of 50 or 100, depending on their size. (See Fig. 8.) The roots of coniferous seedlings are then dipped in a "puddle" of thin mud to prevent drying out. The bunches are then packed in boxes in layers, roots toward the center of the box. Wet sphagnum moss is packed around the roots to keep them moist while in transit. Tops are not moistened.

Shipments of 2,000 or less seedlings are sent by parcel post in paste board boxes. Large shipments are sent by express either in wooden boxes or crates.

Seedlings should never be left in the shipping boxes any longer than necessary, but should be unpacked immediately upon receipt and either planted at once or "heeled in" at or near the planting site.

The number of bundles in the shipment should be counted as removed from the packing boxes and the number of seedlings counted in several bunches. This is to check up the number of seedlings received.

"Heeling in" is done to prevent the roots from drying out. A trench is dug with a spade or plow, deep enough to take care of the roots without crowding. The bundles of seedlings are then taken from shipping boxes, the string cut, and the seedlings spread out along the side of the trench away from the excavated soil with tops above the surface of the ground. (See Fig. 9.) The soil is then pushed into the trench covering the roots and firmed with the foot.

It is best to dip the roots in a "puddle" of thin mud before placing them in the trenches, but keep the tops dry. One bundle of seedlings should be given about six inches of space in the trench.

For "heeling in," select a site close to where the plantation is to be made, and where water is near at hand. It should be partly or wholly under shade but where there is a good circulation of air. The soil should be moist but not wet.

PREPARATION BEFORE PLANTING.

Little previous preparation of the area to be planted is necessary in this State. Occasionally where soil conditions allow, the ground is plowed and harrowed. If this can be done at a nominal cost, say $5 per acre, the plantation may still result in producing a fair rate of interest on the investment. However, such preparation of the area is beneficial only to a comparatively small extent. A large percentage of the planted seedlings may be expected to live and produce a slightly better rate of growth, but this would only be noticeable for a few years after planting. As a rule, it is not advisable.

In other cases, as on scrub oak barrens, all or part of the existing growth is removed and burned. Such clearing of land has been experimented with on State Forests to an extent sufficient to warrant advising against it. (See Figs. 4 and 10). First, the cost of clearing is very high, reaching as much as $50 per acre. This, in itself, makes clearing of the area prohibitive if the plantation is to become financially profitable. Second, it has been found that sprouts from the stumps grow much faster than the planted trees and produce a much denser growth than before clearing. In consequence, the planted trees suffer from lack of sunlight and frequently die.

SPACING.

Various spacing distances for planting are in common use in this State. In most cases an attempt is made to space the seedlings at regular intervals in the rows and the rows are then spaced the same distance apart. This is not always possible, especially in "underplanting," for existing growth prevents regularity. When cleared ground is to be planted, straight rows and regular spacing can be followed.

The number of seedlings required per acre for different spacing distances is shown in the following table.

TABLE NO. 2. NUMBER OF SEEDLINGS PER ACRE WITH DIFFERENT SPACING DISTANCES.

Spacing.	Number per Acre.
3 ft. x 3 ft.,	4,840
4 ft. x 4 ft.,	2,722
5 ft. x 5 ft.,	1,742
6 ft. x 6 ft.,	1,210

Close spacing of trees in plantation is practiced in order that the crowns of the trees may form a closed canopy over the ground in a minimum number of years. The aim is to shade out and kill the lower branches, causing natural pruning to take place. This results in producing lumber comparatively free of knots, also forces height growth of the tree with a minimum amount of taper. Either 4 ft. x 4 ft. or 5 ft. x 5 ft. spacing is recommended for Pennsylvania conditions.

MIXTURE OF SPECIES.

Plantations may be made pure, that is, using one species only, or in mixture, using two or more species in the same plantation. Several different methods of mixing are followed, viz.:

Group mixtures.
Alternating by rows.
Alternating in the rows.

By the group mixture is meant the planting of different species in pure groups, the groups being adjacent to one another, as illustrated by Fig. 1, Plate I.

The method of alternating by rows is illustrated by Fig. 2, Plate I, showing how it may be done when either two or three species are mixed. Fig. 3, Plate I, shows two methods of mixing by alternating in the rows. Innumerable other combinations of mixtures are possible but more or less impracticable. The more complicated the mixture, the greater the cost of planting.

Many factors govern the advisability of planting in mixture. Three of the most important to be considered are:

1. Kind of soil and amount of soil moisture.
2. Light requirements of the species.
3. Rate of growth of the species.

A slow growing intolerant species should not be planted in mixture by the last two described methods, alternate rows or alternating in the rows. But a slow-growing tolerant species may be placed with an intolerant one providing both species are adapted to soil and other conditions of the site to be planted. For instance, white pine and Norway

PLATE I

METHODS OF MIXING SPECIES IN PLANTATIONS.

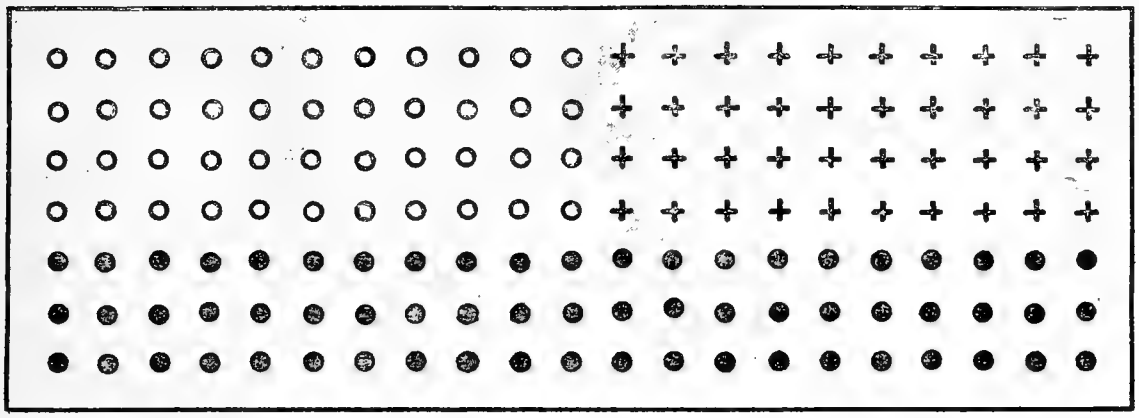
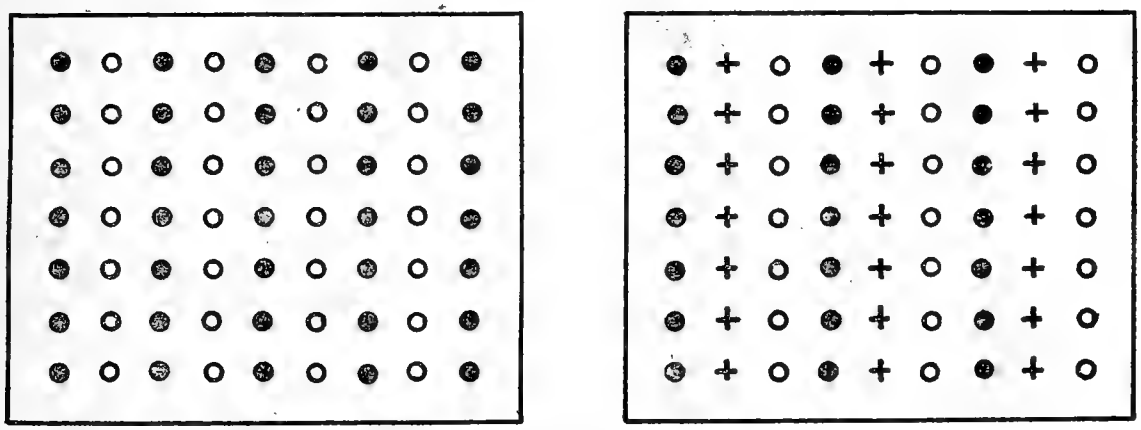
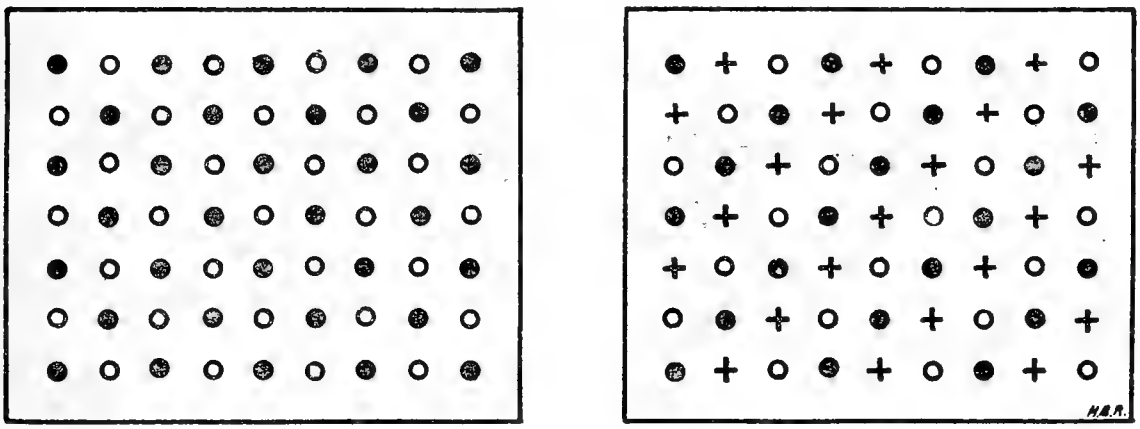


Fig. 1 GROUP MIXTURE.



Using two species. Using three species.

Fig. 2. ALTERNATING BY ROWS.



Using two species. Using three species.

Fig. 3. ALTERNATING IN THE ROW.

Symbols represent different species.

DIGGING THE HOLE IN WHICH TO PLANT A SEEDLING.

Fig. 11. First stroke with the mattock.

Fig. 12. Removing dirt from the hole.

Fig. 13. Placing seedling in the hole.

Fig. 14. Tamping soil around roots, using a stone.

Photo by R. G. Conklin.

Fig. 15. Planting on land cleared of brush.

Photo by R. G. Conklin.

Fig. 16. Planting in brush.

spruce may be mixed with practically all of the species herein advised to plant. Where any particular species is subject to injury or destruction by insects or fungous diseases, it is well to plant such species in mixture with other species not liable to attack by that particular insect or fungus. For example, the white pine weevil is doing considerable damage in this State to white pine. In consequence, it is not advisable to plant white pine in pure stands, but it may be mixed with any of the species herein advised to plant.

METHOD OF PLANTING.

Digging the Hole.—The method of planting adaptable to Pennsylvania conditions is to plant the trees in holes dug with a mattock or grubbing hoe. The method of digging the holes most commonly followed is shown by Figs. 11 and 12. The digging end of of the mattock only is required. One stroke is usually sufficient to loosen the soil, and one or more additional strokes to draw the loosened soil from the hole, leaving it in a mound at the edge. Where planting is to be done in heavy sod, two parallel cuts, six or eight inches long and about four inches apart, should be made with the cutting end of the mattock. A third stroke with the digging end of the mattock turns back the sod.

Setting the Seedling.—The tree to be planted is held between the thumb and finger of the left hand at the root collar (See Figs. 5, 6 and 7), and lowered into the hole until the root collar is level with the ground, the roots resting against the side of the hole. The dirt is then drawn back into the hole with the right hand and firmed about the roots either with a planting mallet or stone, or with the foot. (See Figs. 13 and 14.) The following rules should be observed generally in setting the plant.

1. See that the root collar comes about level with the ground.
2. Spread out the roots, putting them as nearly as possible in the position they originally had in the nursery.
3. See that the roots are pointing downward, not bent upward.
4. Have the stem of the plant as nearly erect as possible.
5. See that soil and not vegetable matter (grass, dead leaves, etc.) comes into contact with the roots.
6. Try to bring moist soil into contact with the roots.
7. Firm the soil well around the roots so that the plant cannot easily be pulled out.
8. Keep the roots moist until planted.

The Planting Crew.—The number of men required in the planting crew depends upon the extent of the planting. Experienced men on different classes of land will plant anywhere from 500 to 1,000 seedlings in a day. The better the planting conditions, the greater the number which may be planted per man per day. One man can

plant about as fast as another can dig the holes (See Figs. 15 and 16). In consequence the crew is made up of about the same number each of mattock men and planters. As a rule, two experienced men should be provided for each 10,000 seedlings to be planted. If 100,000 seedlings are to be planted, the crew should include ten mattock men and ten planters.

In addition to the mattock men and planters, an additional man or boy is sometimes provided for each five planters. It is his duty to carry the seedlings to the planters and to drop one in each hole. The plants are usually carried in buckets partly filled with thin mud, called "puddle." If there are ten planters, two "droppers" or plant distributors should be provided. One foreman to every twenty men should be charged with the duty of seeing that the seedlings are properly planted.

COST OF PLANTING.

Planting costs vary widely with the many different soil and growth conditions encountered. Where abandoned farm lands are to be planted, the ground may be plowed and harrowed, making planting easy and usually cheaper. Of course, this preparation of the soil, plowing and harrowing, is an item of expense against the planting, but even with this included, the cost should be less than when planting is done where the soil is stony, or where the existing growth is scrub oak, etc.

On Pennsylvania State Forests planting has been done under conditions many and varied, and usually more or less adverse. In all costs herein given for State forest planting, supervision charges are included. The cost of planting per thousand seedlings has varied widely for the different Forests in different years. The first planting on State Forests was done in 1899. Since that time to the end of the year 1915, a total of 16,553,291 seedlings were planted at a cost of $52,919.25, making an average of $3.20 per thousand for planting. For 1915 alone, the average cost was $2.95 per thousand. In that year a total of 4,349,386 seedlings were planted, so this average cost per thousand is a very fair one. The lowest cost was obtained on the Pine Grove Forest where girls and boys were used, the average for planting 141,500 seedlings being $1.28 per M. This was unusually low and is not a fair criterion of cost. Where small plantations, say of only a few thousand seedlings, are made, the cost will run higher than for large ones.

The cost of planting per acre depends also on the spacing which regulates the number of seedlings required per acre. As a rule, either 4 ft. x 4 ft. or 5 ft. x 5 ft. spacing is recommended. Where 4 ft. x 4 ft. spacing is used, 2,722 seedlings are required and the planting cost per acre would be about $8.00. If 5 ft. x 5 ft. spacing is fol-

lowed, 1,740 seedlings are used and the cost would average about $7.00. But it should not be overlooked that to produce lumber free of knots close planting of the seedlings is required.

The cost of planting, of course, is a factor regulating the financial returns from the investment and to gain the best possible rate of interest on the investment requires the lowest possible cost for making the plantation. However, careful planting must not be sacrificed to keep down the cost a dollar or two per acre. The success of the plantation depends largely on the care given the seedlings before planting and that with which the seedlings are planted.

RATE OF GROWTH.

The rate of growth of planted trees varies widely for different species on different soils and on the different classes of land. Slow growth may be expected on poor soils. However, soils considered too poor for agriculture may be good for wood production. Even though the soil be regarded good for forest trees, if the growth present before planting is bracken or scrub oak, slow growth may be expected until the planted trees are able to overtop the weed species and thus get the advantage of more sunlight (see Fig. 17). On the other hand, on the more open sites, as abandoned farm lands usually are, rapid growth may be expected.

The rate of growth of a number of different species of trees planted on various sites is shown by Tables Nos. 3 to 8 inclusive. These tables were prepared from measurements taken in plantations during the fall of 1916 on Pennsylvania State Forests and on the Jacob Nolde Estate, Berks County, Pa. Average heights are based on measurements of from 100 to 500 trees.

At the head of each column of heights is given a very brief description of the site planted and the age of the planting stock. The "Age of Trees from Seed," given in the first column, is the number of growing seasons through which the trees have passed, including years in the nursery.

The reason for presenting these tables is to give the layman an idea of the rate of growth which he may expect for his plantations. On very favorable sites, a more rapid rate of growth may be counted on than given in the tables. A slower growth rate may be obtained where the plantation is made under more adverse conditions. It will be noted that very slow growth is usually had in plantations the first three to five years after planting, the trees requiring time to adapt themselves to changed conditions. Frequently no appreciable growth whatever is made during the first year or two. When they once become established and overtop brush and weeds, rapid growth, that is, a foot or more a year, may be expected.

TABLE NO. 3. HEIGHT GROWTH OF WHITE PINE (P. STROBUS) IN FOUR DIFFERENT PLANTATIONS.

Age of Trees from Seed (Years).	Description of the Plantations.			
	Mont Alto State Forest. Soil—Sandy loam. Area originally cultivated. Altitude 1600 ft. Aspect—S. E. 2 yr. seedlings planted in 1902, spaced 4′x 4′.	Caledonia State Forest. Soil—shale and loam. Area originally cultivated. Aspect—Western. 2 yr. seedlings planted in 1906, spaced 4′x 4′.	Greenwood State Forest. Soil—rich sandy loam, heavy sod. Area originally cultivated. Altitude 1,000 ft. Aspect — Southern. 2 yr. seedlings planted in 1909, spaced 4′x 4′.	Jacks Mountain State Forest. Soil — dry, very sandy. Brush land, severely burned. Altitude 1,500 ft. Aspect — Northern. 2 yr. seedlings planted in 1909, spaced 4′x 4′.
	Average Heights at End of Year's Growth (feet).			
3	.4	....	....	.2
4	.6	....	1.1	.4
5	1.2	....	1.2	.6
6	1.9	....	1.5	.9
7	2.8	2.2	2.1	1.0
8	4.0	3.6	2.8	1.3
9	5.3	5.3	3.7	1.5
10	6.6	6.7	5.1	1.8
11	7.6	8.0	....	....
12	8.8	9.6	....	....
13	10.1	11.8*	....	....
14	11.3	....	....	....
15	12.3	....	....	....
16	13.5	....	....	....
17	14.9‡	....	....	....

‡Average diameter, 4½ ft. above ground, in 1916, was 2.4 inches. See Figs. 22, 23, 24 and 25.
*Average diameter, 4½ ft. above ground, in 1916, was 1.9 inches.

TABLE NO. 4 HEIGHT GROWTH OF SCOTCH PINE (P. SYLVESTRIS) IN FOUR DIFFERENT PLANTATIONS.

Age of Trees from Seed (Years).	Description of the Plantations.			
	Mont Alto State Forest. Soil—sandy loam. Area originally cultivated. Altitude 900 ft. Aspect—S. E. 2 yr. seedlings planted in 1909, spaced 4′x 4′.	Stone State Forest. Soil — shallow loam. Area grown up with sod and brush. Altitude 1,200 ft. Aspect—N. W. 2 yr. seedlings planted in 1909, spaced 5′x 5′.	Pennypacker State Forest. Soil — blue and red shale. Area originally cultivated. Altitude—1,050 ft. Aspect—S. E. 2 yr. seedlings planted in 1909, spaced 4′x 4′.	Jacks Mountain State Forest. Soil — dry, very sandy. Brush land, severely burned. Altitude 1,500 ft. Aspect — Northern. 2 yr. seedlings panted in 1909, spaced 4′x 4′.
	Average Heights at End of Year's Growth (feet).			
3	.7	.6	....	.5
4	1.0	1.0	1.4	.7
5	1.6	1.7	2.0	1.2
6	2.7	2.7	3.0	1.5
7	4.1	3.7	4.4	1.8
8	6.1	4.9	5.8	2.1
9	8.3	6.4	7.8	2.6
10	10.9	7.8	10.3	3.1

TABLE NO. 5. HEIGHT GROWTH OF PITCH PINE, BULL PINE, AND JACK PINE IN PLANTATIONS.

Age of Trees from Seed (Years).	Description of the Plantations.			
	Pitch Pine (P. rigida).	Bull Pine (P. ponderosa).		Jack Pine (P. Banksiana).
	White Deer State Forest. Soil—sandy. Scrub oak area. Altitude 2,000 ft. Practically level. 2 yr. seedlings planted in 1913, spaced 5′x 5′.	Mont Alto State Forest. Soil—sandy. Area originally cultivated. Altitude 950 ft. Aspect—S. E. 2 yr. seedlings planted in 1908, spaced 5′x 5′.	Jacob Nolde Estate, Reading, Pa. Soil—sandy loam. Area originally cultivated. Altitude 800 ft. Practically level. 2 yr. seedlings planted in 1911, spaced 3½′x 4′.	Jacob Nolde Estate, Reading, Pa. Soil—sandy loam. Area originally cultivated. Altitude 800 ft. Aspect—S. W. 2 yr. seedlings planted in 1910, spaced 3′x 4′.
	Average Heights at End of Year's Growth (feet).			
1	.6			
2	.9	.4	.4	....
3	1.5	.7	.7	....
4	2.0	1.1	1.3	....
5	2.4	1.3	2.1	....
6	....	1.8	3.0	....
7	....	2.4	4.3	5.8
8	....	3.0	5.7*	8.0
9	....	3.8	....	10.4‡
10	....	4.5	....	....
11		5.5	....	....

*See Fig. 28.
‡Average diameter, 4½ ft. above ground, was, in 1916, 1.3 inches. See Fig. 27.

TABLE NO. 6. HEIGHT GROWTH OF EUROPEAN LARCH AND JAPANESE LARCH IN PLANTATIONS.

Age of Trees from Seed (Years).	Description of the Plantations.			
	European Larch (Larix decidua).			Japanese Larch (Larix leptolepis).
	Mont Alto State Forest. Soil — moist, sandy loam. Area originally cultivated. Altitude 900 ft. Aspect—S. E. 2 yr. seedlings planted in 1909, spaced 4′x 4′.	Stone State Forest. Soil—dry, sandy loam. Area grown up with brush and sod. Altitude 1,100 ft. 3 yr. seedlings planted in 1910, spaced 4′x 4′.	Austin State Forest. Soil—red shale. Brush land cleared previous to planting. Altitude 1,300 ft. Aspect—S. W. 2 yr. seedlings planted in 1910, spaced 4′x 4′.	Jacob Nolde Estate, Reading, Pa. Soil—deep sandy loam. Area cleared of brush previous to planting. Altitude 700 ft. Aspect—N. E. 2 yr.. seedlings planted in 1909, spaced 3½′x 4′.
	Average Heights at End of Year's Growth (feet).			
3	.5		....	....
4	.7	1.0	1.4	....
5	1.2	1.7	1.7	....
6	2.0	2.7	1.9	....
7	2.8	3.8	2.1	....
8	4.9	5.7	3.0	....
9	7.1	8.2	4.6	....
10	9.6	10.4	6.3	16.9*

*Average diameter, 4½ ft. above ground, was, in 1916, 1.6 inches.

TABLE NO. 7. HEIGHT GROWTH OF NORWAY SPRUCE AND DOUGLAS FIR IN PLANTATIONS.

Age of Trees from Seed (Years).	Description of the Plantations.			
	Norway Spruce (Picea Abies).			Douglass Fir (Pseudotsuga taxifolia).
	Austin State Forest. Soil—red shale. Site originally farmed. Cultivated. Altitude 1,300 ft. Aspect—S. E. 3 yr. seedlings planted in 1910, spaced 4′x 4′.	Stone State Forest. Soil—sandy loam. Brush land. Altitude 1,130 ft. Aspect — Northern. 3 yr. seedlings planted in 1910, spaced 5′x 5′.	Jacob Nolde Estate, Reading, Pa. Soil—sandy loam. Brush land, cleared before planting. Altitude 700 ft. Aspect—Eastern. 4 yr. transplants planted in 1909, spaced 3½′x 4′.	Jacob Nolde Estate, Reading, Pa. Soil—sandy loam. Area originally cultivated. Altitude 750 ft. Aspect—N. E. Trees 7 years old transplanted in 1915, spaced 5′x 5′.
	Average Heights at End of Year's Growth (feet).			
2	....	....	....	.7
3	.3	....	....	.8
4	.3	....	....	.9
5	.3	1.3	1.1	1.3
6	.4	1.7	1.3	2.0
7	.7	2.0	1.7	3.0
8	1.0	2.4	2.2	3.2
9	1.3	2.9	2.9	3.7*
10	2.6	3.7	3.9	....
11	....	....	4.9	....
12	....	....	5.9‡	....

‡See Fig. 30.
*See Fig. 29.

TABLE NO. 8. HEIGHT GROWTH OF WHITE ASH, BLACK WALNUT, AND BLACK CHERRY IN PLANTATIONS.

Age of Trees from Seed (Years).	Description of the Plantations.			
	White Ash (Fraxinus americana).		Black Walnut (Juglans nigra).	Black Cherry (Prunus serotina).
	Stone State Forest. Soil—heavy sandy loam. Area originally cultivated. Altitude 1,140 ft. Aspect—Eastern. 2 yr.. seedlings planted in 1909, spaced 5′x 5′.	Mont Alto State Forest. Soil—sandy loam. Area originally cultivated. Altitude 1,000 ft. Aspect—Eastern. 1 yr. seedlings planted in 1905, spaced 4′x 4′.	Mont Alto State Forest. Soil—sandy loam. Area originally cultivated. Altitude 950 ft. Aspect—Eastern. 1 yr. seedlings planted in 1907, spaced 5′x 5′.	Stone State Forest. Soil—dry shallow sandy loam. Area covered with brush and sod. Altitude—1,140 ft. Aspect—Western. 1 yr. seedlings planted in 1910, spaced 4′x 4′.
	Average Heights at End of Year's Growth (feet).			
1	....	.3	.3	....
2	....	.5	.6	.3
3	.9	.8	.8	.4
4	1.9	1.1	1.2	.5
5	2.9	1.4	1.8	.6
6	4.4	2.0	2.7	.7
7	5.8	2.8	3.5	.9
8	7.9	3.8	4.0	1.6
9	10.4	4.6	4.5	....
10	13.9*	6.1	4.8	....
11	....	7.0	....	....
12	....	7.7	....	....
13	....	8.2	....	....

*Average diameter, 4½ ft. above ground, was, in 1916, 1.5 inches.

Fig. 17. WHITE PINE PLANTED IN BRACKEN AND SWEET FERN.

Three year old stock was used and four years later the trees were just overtopping weeds and brush. Clearfield State Forest.

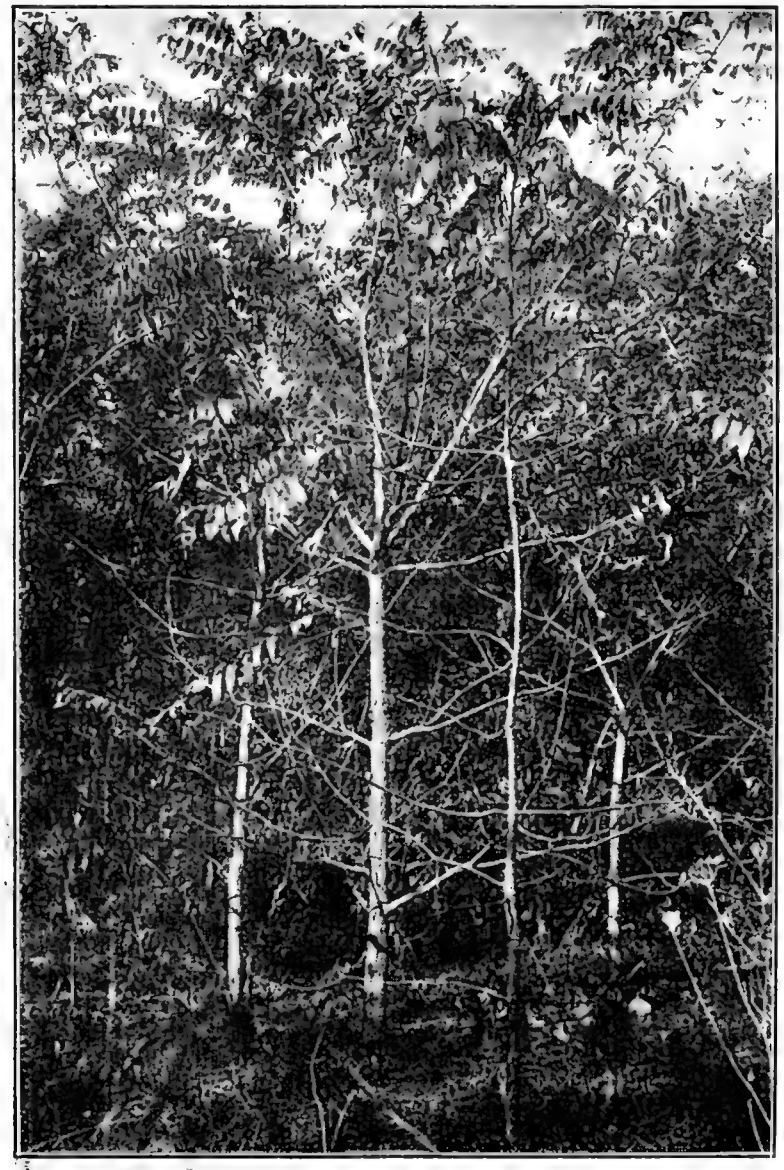


Fig. 18. PLANTATION OF BLACK WALNUT.

Trees ten years old from seed. The plantation was made in 1908, using 1 year stock. Mont Alto State Forest.

Photo by G. C. Hawkins.

Fig. 19. A NORWAY SPRUCE PLANTATION IN GERMANY.

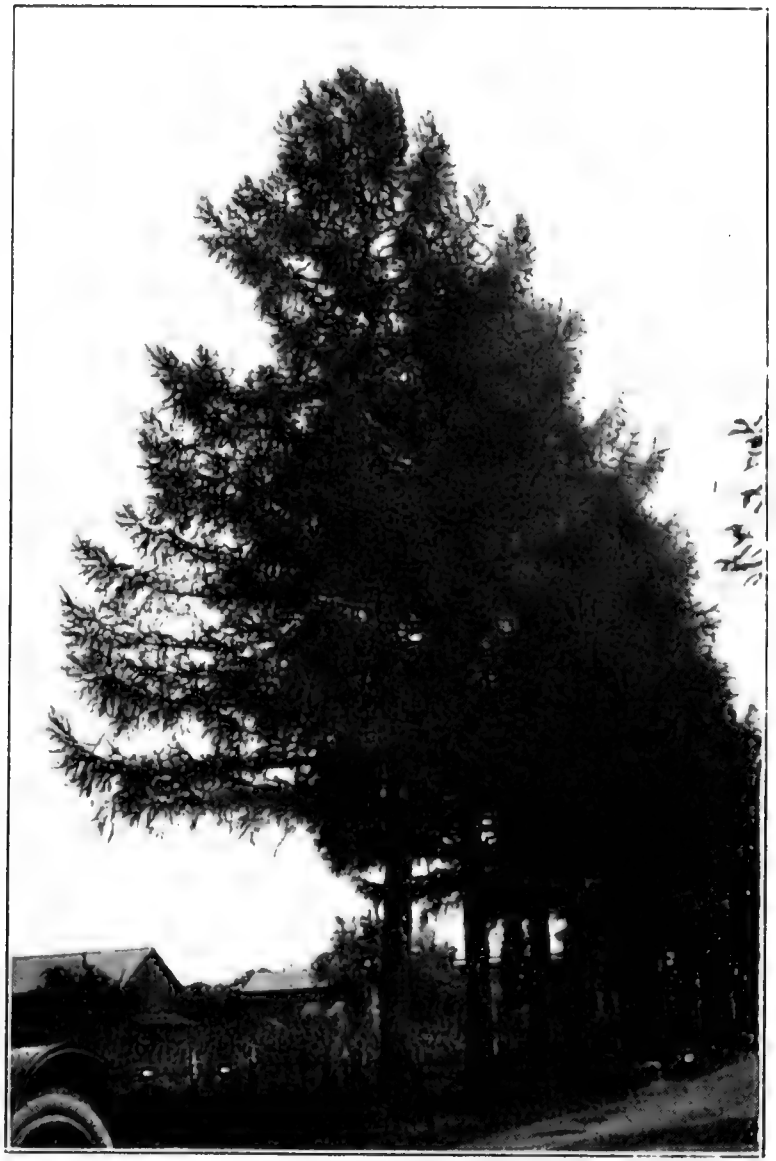


Fig. 20. EUROPEAN LARCH IN PENNSYLVANIA.

Photo by J. S. Illick.

Fig. 21. WHITE PINE PLANTATION.
Two year old seedlings were used. The trees are 58 years old.

WHITE PINE PLANTATION MADE IN 1902. MONAGHAN FIELD, MONT ALTO STATE FOREST.

Photo by F. A. Drachbar.

Fig. 22. This picture was taken two years after planting, the trees being four years old from seed. Average height was seven inches.

Photo by Dr. J. T. Rothrock.

Fig. 23. This picture shows the plantation six years after planting. The trees were eight years old. Average height four feet.

WHITE PINE PLANTATION. MONAGHAN FIELD, MONT ALTO STATE FOREST.

Photo by Geo. H. Wirt.

Fig. 24. When this picture was taken the trees had been planted nine years and were eleven years old. Average height 7.6 feet.

Photo by J. S. Illick.

Fig. 25. This picture was taken in the fall of 1916 when the trees were seventeen years old. The average height of the trees was 14.9 feet and the average diameter, 4½ feet above ground, was 2.4 inches.

Photo by J. E. McNeal.

Fig. 26. PLANTATION OF SCOTCH PINE

Trees nine years old from seed. Average height nine feet. Average diameter 1.2 inches. Jacob Nolde Estate, Berks County, Pennsylvania.

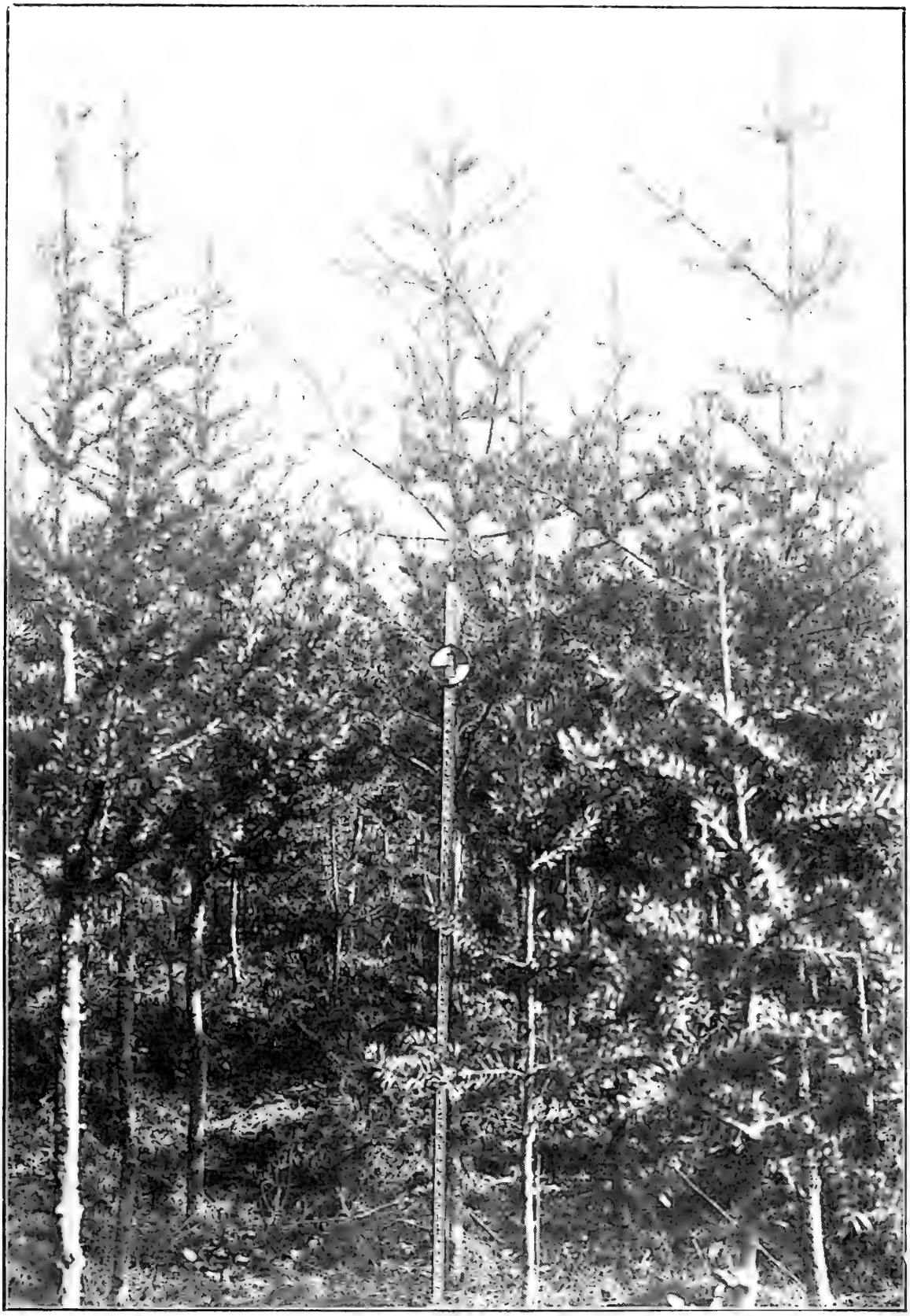


Photo by J. E. McNeal.

Fig. 27. PLANTATION OF JACK PINE.

Trees nine years old. Average height 10.4 feet. Average diameter 1.3 inches. Jacob Nolde Estate, Berks County, Pennsylvania.

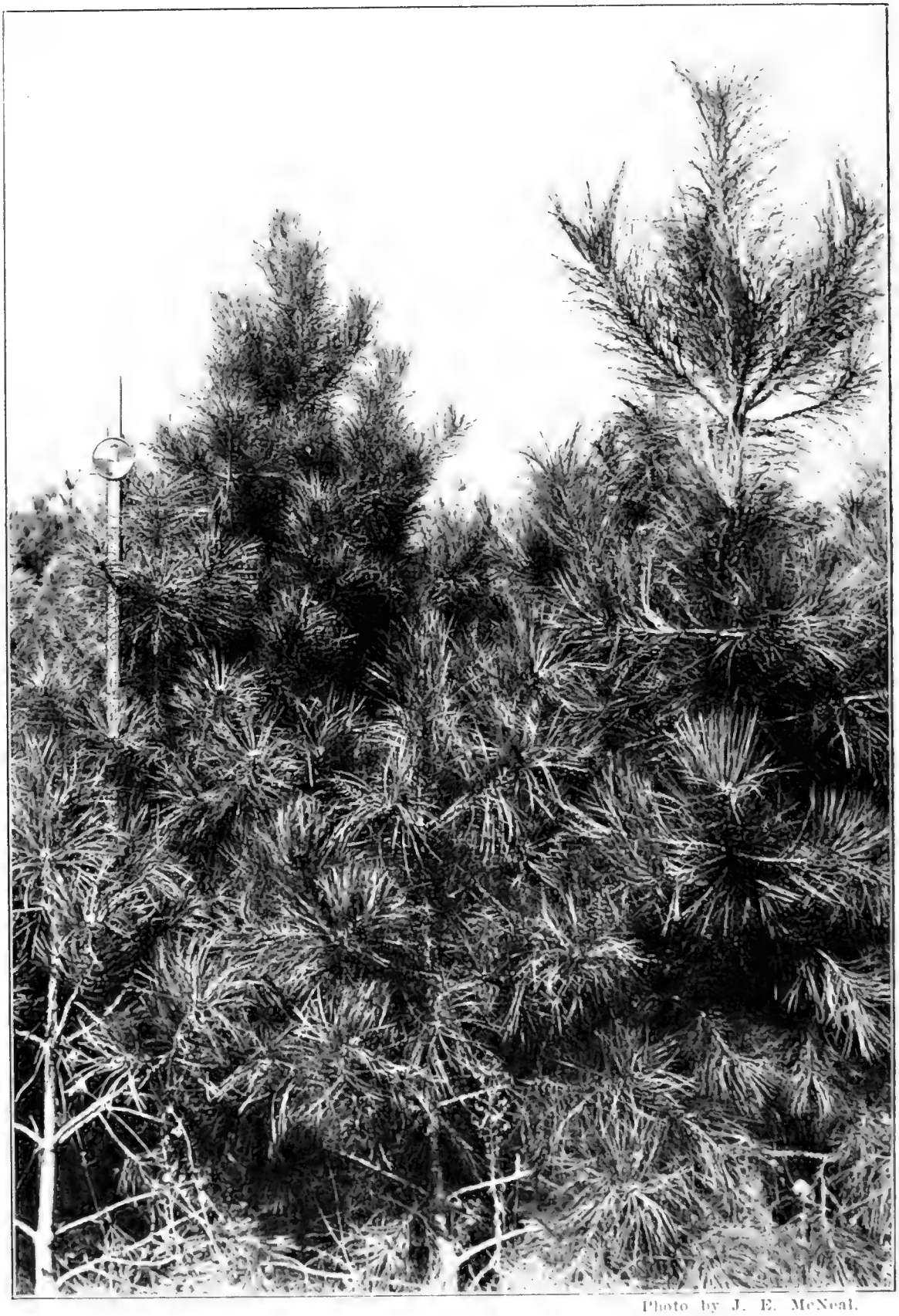


Photo by J. E. McNeal.

Fig. 28. PLANTATION OF BULL PINE.

Trees eight years old. Average height 5.7 feet. Jacob Nolde Estate, Berks County, Pennsylvania.

Photo by J. E. McNeal.

Fig. 29. PLANTATION OF DOUGLAS FIR.

Trees nine years old. Average height 3.7 feet. Jacob Nolde Estate, Berks County, Pennsylvania.

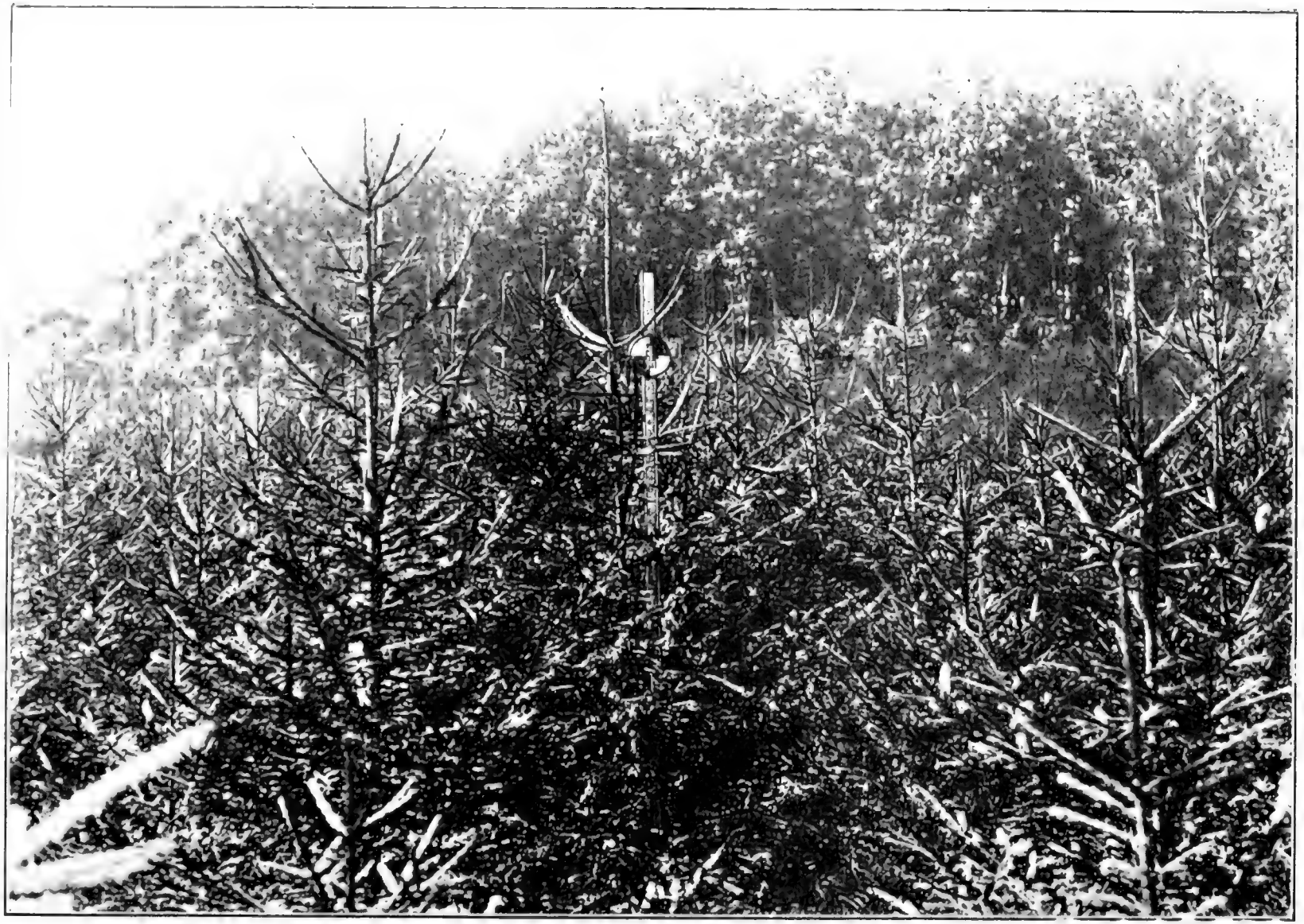


Photo by J. E. McNeal.

Fig. 30. PLANTATION OF NORWAY SPRUCE.

Trees eleven years old Average height 5.9 feet. Jacob Nolde Estate, Berks County, Pennsylvania.

PROTECTION OF THE PLANTATION.

The success or failure of the plantation is directly dependent on various external dangers which may injure the trees or destroy them entirely, either as a whole, or in part. Among the factors of danger most to be guarded against are:

Fire—First and foremost.
Grazing.
Gnawing animals.
Insects.
Fungi.

FIRE.—No reforestation project should be undertaken unless the planting site be so protected that danger of fire is minimized. One fire running over the surface of the ground, feeding on leaf litter and other inflammable debris, means almost certain destruction of the planted trees. The absolute necessity of providing an adequate system of protection from fire cannot be too strongly brought to the attention of the planter. Space here does not warrant going into details of protective measures. They are too voluminous, and, too, each site has its own particular protective necessities. Such information may be obtained by addressing the Bureau of Forest Protection, Department of Forestry, Harrisburg, Pa.

GRAZING.—Grazing of cattle over land planted to forest trees should not be permitted, at least not until the trees have reached a height of fifteen to twenty feet. In young plantations, cattle may either eat or trample down the small trees, resulting in the destruction of all or part of the plantation.

GNAWING ANIMALS.—Hardwood plantations in this State have occasionally been damaged by rabbits and mice gnawing the bark and frequently girdling the small tree. Such damages are usually prevalent during severe winters when snow makes other food difficult of access. In coniferous plantations little damage has been reported from this cause.

INSECTS.—Numerous insects do more or less damage in plantations of all species, both young and old, some attacking the foliage, while others work in the bark or wood of the stems. The work of certain insects results in death to the tree while others do only temporary injury. Special attention is called to the destructive ravages of the white pine weevil (Pissodes strobi) which has been the greatest source of insect damage in white pine plantations in Pennsylvania. This insect works particularly on young white pines, although its activities are not confined to them alone. It is quite common on old trees and has been found in several State forest plantations of Scotch pine and to a more limited extent on Norway spruce.

The adult beetle is about ¼ inch in length, of a reddish brown color, and somewhat mottled with white. The female beetle deposits her eggs in the bark, usually of the terminal shoots, in the spring. The eggs develop into grubs during the month of June. The grubs eat their way obliquely toward the center of the shoot and downward into the pith for a half inch or so. A great many eggs are usually deposited in each shoot and the numerous grubs resulting completely destroy the shoot. Frequently they destroy lateral branches also and sometimes are found in preceding years' growths.

Trees attacked by the weevil cannot easily be detected until after the first few weeks in July, when the shoots begin to wilt and turn brown. Examination of the shoots, by making longitudinal cuts in the shoot, will reveal the plump white grub. White pine and Scotch pine plantations, particularly, should be carefully searched for signs of the weevil about the middle of July and August. All shoots turning, or turned brown, should be cut close to the last whorl of branches and burned. Grubs and partly matured beetles in the shoots are thereby destroyed and their spread checked. Many birds are natural enemies of insects, destroying great numbers of them. Protect the birds and they will help protect the trees.

Fungi.—Various fungous diseases are found on certain species of trees which it has been suggested to plant. Some do only temporary damage while others cause speedy death to the attacked tree. No attempt will be made to enter into a discussion of the many possible fungous diseases. However, attention of all persons interested in the planting of white pine is called to the white pine blister rust, a fungus which has been brought from Europe on imported nursery stock. Its spread in this country endangers our white pine, and it has been reported in several parts of Pennsylvania but only as isolated infections. A close watch should be kept for this disease to prevent its spread.

This fungus has two hosts, the five needled pines and wild and cultivated currants and gooseberries, upon which it completes its life cycle. On pines, its appearance may be detected by the presence of irregular swellings of the bark. In the spring, from the latter part of April to the middle of June, fruiting bodies appear on these swellings. Whitish blisters, about ⅛ to ¼ of an inch across, first appear, which change to orange color in a few days. By the middle of June, the orange colored postules, which are spores, each one capable of producing the disease, disappear, leaving small rounded hollows on the infected part of the tree. These spores do not infect pines, but attack leaves of currants and gooseberries. Young pines attacked by the blister rust are almost invariably killed, either the first or second year. Old trees may have branches only infected, but usually the infection spreads, finally killing the tree.

The spread of this fungus is impossible unless there are currants and gooseberries upon which it can pass a part of its life cycle. Therefore to check its spread, all currants and gooseberries in the vicinity of the plantation of white pines should be destroyed.

A very complete description of the white pine blister rust is given in Farmers' Bulletin No. 742, U. S. Department of Agriculture. If the presence of the disease is suspected in any part of Pennsylvania, notify the Commissioner of Forestry, Harrisburg, Pa.

All persons interested in reforestation in Pennsylvania who find destructive agencies, such as insects or fungous diseases, working in trees, are requested to bring the matter to the attention of the Commissioner of Forestry. A description of the character and extent of the damage being done should be given. Where possible, a specimen of the infected part of the tree should accompany this information.

PART II.

WHERE AND HOW TO OBTAIN PLANTING STOCK.

Small trees for forest planting may be obtained from the Pennsylvania Department of Forestry. Five large nurseries for the production of forest tree seedlings and transplants are maintained by the Department. In addition, twenty of the State Forests have small nurseries. Trees from these nurseries, over and above what is needed for State forest planting, are furnished to individuals free of charge for private planting in Pennsylvania. This is provided for by an Act of the legislature approved April 21, 1915, as follows:

AN ACT

Authorizing the Department of Forestry to grow and distribute young forest trees, and restricting their use after distribution.

Section I. Be it enacted, &c., That the Department of Forestry is hereby authorized to grow young forest trees, and to distribute them to those desiring to plant them, in such quantity and under such regulations as may be prescribed by the Department, when the available stock in the forest nurseries shall be in excess of that required by the Department for forest planting. No charge shall be made for the trees so distributed, but the cost of boxing and shipping shall be paid by the applicant. The applicant must enter into an agreement with the Department to plant the young trees under such conditions or regulations as may be made by the Department,

and to protect and care for them when planted. The Department may render such assistance and instruction in the planting of the trees as it may deem necessary to secure their proper planting.

Section 2. That all such young forest trees, which shall be distributed as aforesaid, shall not be subject to sale in the hands of the applicant, but shall be properly planted, in accordance with the agreement entered into with the Department.

Section 3. That all acts and parts of acts inconsistent with or supplied by this act are repealed.

Approved—The 21st day of April, A. D. 1915.

MARTIN G. BRUMBAUGH.

The annual production from State owned nurseries is 6,000,000 to 8,000,000 seedlings and transplants. In 1916, a total of 6,946,295 were removed from State nurseries, of which 1,454,275 were given to individuals in the State.

The stock grown in these nurseries is not suitable for purely ornamental planting, and applications for trees for this purpose will not be granted. They are grown for, and are to be used only for afforestation, and this only within the State.

HOW TO OBTAIN PLANTING STOCK.

Forest tree seedlings and transplants can be furnished from any one of the State owned nurseries.

Persons who own waste land in Pennsylvania and who desire to reforest it, should report to the Department of Forestry at Harrisburg, or to the nearest State Forester named below.

James E. McNeal, Distict Forester, No. 616 Washington St., Reading, Berks county. Mr. McNeal's district includes Berks, southern Carbon, Lehigh, Northampton, and Schuylkill counties.

R. Lynn Emerick, District Forester, Coudersport, Potter county. Mr. Emerick's district includes Potter and McKean counties.

Walter D. Ludwig, District Forester, care of Chamber of Commerce, Johnstown, Cambria county. Mr. Ludwig's territory includes Cambria, Blair, and Indiana counties.

Wm. F. Dague, District Forester, Clearfield, Clearfield county. Mr. Dague has charge of Clearfield county interests.

John L. Strobeck, District Forester, Analomink R. F. D., Monroe county. Mr. Strobeck's territory includes Monroe, northern Carbon, and parts of Lackawanna and Wayne counties.

John E. Avery, Notch, Pike county.

L. G. Barnes, Box 33, Centre Hall, Centre county.

W. J. Bartschat, Troxelville, Snyder county.

Chas. E. Baer, Elimsport, Lycoming county.

John A. Bastian, Loyalsock, Lycoming county.

V. M. Bearer, Ligonier, Westmoreland county.

Fig. 31. These beds contain thousands of seedlings. European larch, two years old.

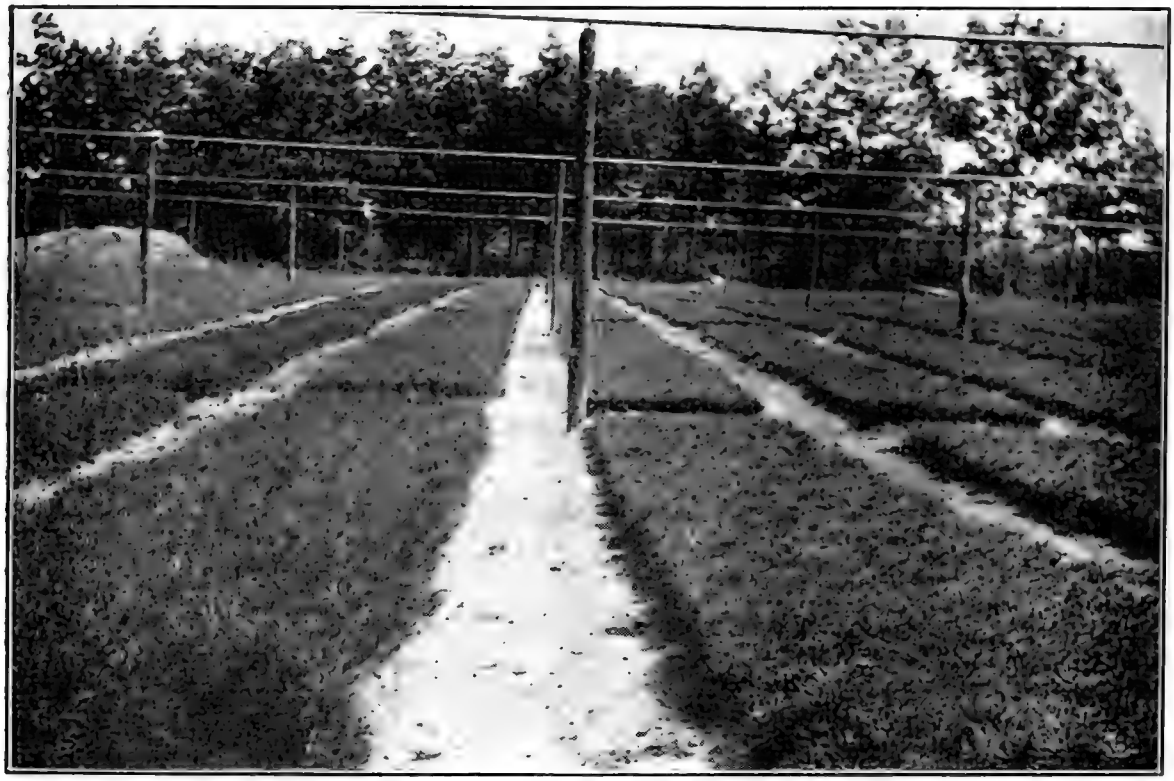


Fig. 32. Pitch pine, two years old. To be removed from the beds in the spring and planted in their final location.

Tom O. Bietsch, McAlevysfort R. F. D. No. 1, Huntingdon county.
Joe R. Blouse, Glen Union, Clinton county.
A. W. Bodine, Mount Union R. F. D., Huntingdon county.
H. E. Bryner, New Germantown, Perry county.
Wm. L. Byers, Rainsburg, Bedford county.
Robert G. Conklin, Fayetteville, Franklin county.
H. F. Critchley, North Bend, Clinton county.
F. H. Dutlinger, Westport, Clinton county.
Harry E. Elliott, Sinnamahoning, Cameron county.
W. B. Evans, Sizerville, Cameron county.
P. Hartman Fox, Austin, Potter county.
Thos. H. Golden, Crossfork, Potter county.
Thos. C. Harbeson, Lloyd, Tioga county.
J. R. Hogentogler, Loganton R. F. D. No. 2, Clinton county.
W. H. Horning, Karthaus, Clearfield county.
J. S. Illick, Mont Alto, Franklin county.
John W. Keller, Boalsburg, Centre county.
Carl L. Kirk, Penfield, Clearfield county.
Chas. R. Meek, Coburn, Centre county.
Homer S. Metzger, Loganton R. F. D. No. 1, Clinton county.
W. E. Montgomery, Spring Mills R. F. D. No. 1, Centre county.
Howard H. Morgan, Slate Run, Lycoming county.
T. Roy Morton, Petersburg, Huntingdon county.
Marvin H. Moyer, Slate Run, Lycoming county.
Paul H. Mulford, Asaph, Tioga county.
Max E. Müller, Hammersleyfork, Clinton county.
Robert R. Neefe, Waterville, Lycoming county.
Geo. S. Perry, Aitch, Huntingdon county.
Geo. A. Retan, Mont Alto, Franklin county.
Alfred E. Rupp, Fort Loudon, Franklin county.
J. B. Ryon, Sinnamahoning, Cameron county.
Geo. W. Sheeler, Snow Shoe, Centre county.
A. C. Silvius, Laurelton, Union county.
H. A. Smith, East Waterford, Juniata county.
Robert W. Stadden, Greentown, Pike county.
Lewis E. Staley, Mont Alto, Franklin county.
H. C. Van Horn, Conrad, Potter county.
D. Kerr Warfield, Milroy, Mifflin county.
A. B. Wells, Fields Station, Lycoming county.
John R. Williams, Pine Grove Furnace, Cumberland county.
Raymond B. Winter, Mifflinburg, R. F. D., Union county.
Chas. E. Zerby, Medix Run, Elk county.

Blank forms for making application for seedlings and transplants will, on request, be furnished by the Department of Forestry, or by any one of the above named foresters. The application, properly

filled out, must be forwarded to the Department of Forestry, Harrisburg. Foresters and nurserymen are not invested with the right to grant free distribution of planting stock. This may be done only by the Commissioner of Forestry.

ADVICE AND EXAMINATION.

Extensive planting operations should not be undertaken by the layman without receiving advice from a competent person trained in the theory and practice of forestry. Reforesting costs money, and a mistake in judgment as to what and how to plant may mean complete failure of the plantation and a heavy loss in money and time. A trained forester cannot guarantee the success of a plantation, for failure sometimes occurs from no apparent cause, or as the result of insect and fungous attacks. However, it is indisputable that reliance on a forester's knowledge presupposes the planting of the best species for the site and, therefore, the best chance of success.

The Department of Forestry is willing to give all possible assistance to individuals in planting operations. Where it is proposed to plant up areas of considerable size, the Department will make every effort to have one of its foresters make an examination of the area to be planted, and do this free of charge. The forester will then make a report to the Department on his examination, suggest the species it is proposed to plant, and furnish a planting plan to be followed. He will also give the individual what advice he can on how best to plant, the number of men necessary to do the planting, and how to organize the crew.

Since the Department of Forestry has only a limited number of foresters available for making examinations, application for examinations and advice should be made at least three months before the planting season. In districts where there is a district forester, he should first be consulted for advice, since the matter will be referred to him.

WHAT IS REQUIRED OF THE RECIPIENT.

In return for receiving seedlings from the Department of Forestry, all persons are required to pay the cost of packing and transportation, and furnish reports requested of them. The seedlings will be shipped from one of the State nurseries. About four days previous to shipment, the nurseryman will inform the applicant of the date of shipment. On the day of shipping, he will mail two blank forms which must be filled in. One is to be used to acknowledge receipt of the nursery stock (B. of S. & M. Form 52, "Nursery Stock Receipt"). The other is for making report on the planting of the seedlings (B. of S. & M. Form 34-B, "Plantation Report for Private Planting").

Nursery Stock Receipt.—On receipt of the shipment, the packing box should be examined. Then several bundles of seedlings should be opened and the number of seedlings in the bundles counted. It will be found that the bundles contain 50, 75, or 100. Occasionally a few extra seedlings of small size are in the bundles. These should not be considered. After determining the number in each bundle, "heel in" all seedlings, counting the number of bundles as this is done. The total number of seedlings received is then known.

The blank form, "Nursery Stock Receipt", should be filled out immediately and mailed to the Commissioner of Forestry, Harrisburg. Make note thereon of the condition of the packing box and the number of seedlings received, and their condition.

Nursery Charge.—The amount of the charge for packing and shipping will be supplied by the nurseryman. As a rule, the packing and hauling to point of shipment averages about 25c per thousand seedlings. Transportation by mail or express averages about 20c per thousand. If sent prepaid, this cost will be included in the amount of the charge sent by the nurseryman. This amount is to be remitted to the Commissioner of Forestry and should accompany the "Nursery Stock Receipt." Remittance may be made by postage stamps if it amounts to less than 50c. If the charge is 50c or over, remittance should be made by check or postal money order.

Plantation Report for Private Planting.—Directly after the seedlings are planted, the blank form provided for this purpose is to be filled out and mailed to the Commissioner of Forestry, Harrisburg. It is imperative that no delay in planting take place and that the report be submitted promptly.

The matter of making full and complete report is important and requires careful attention. Keep account of all costs incurred, including drayage from station to planting site, hired labor, and the number of hours devoted to planting by salaried employees. Calculate what this time is worth and indicate it in the space provided on the blank.

Give a description of the plantation as called for on the form. The information conveyed by these reports will be a matter of record at the Department of Forestry. We desire complete and accurate reports.

SPECIES USUALLY AVAILABLE FOR FREE DISTRIBUTION.

All species listed under "Species to Plant" are not grown in State nurseries. The following species are usually available for free distribution.

White pine, ...2 and 3 years old.
Scotch pine, ...2 years old.
Pitch pine, ...2 years old.
Norway spruce, ...3 years old.
European larch, ...2 years old.

The following species are occasionally available but in more limited numbers.

Red pine, ...2 and 3 years old.
Japanese larch, ...2 years old.
Bull pine, ...2 years old.
Sugar maple, ...1 and 2 years old.
White ash, ...1 and 2 years old.
Red oak, ...1 and 2 years old.
Honey locust, ...1 and 2 years old.
Black cherry, ...1 and 2 years old.

POINTS TO BEAR IN MIND.

1. Trees are furnished for forest planting only, not for shade or ornamental purposes.
2. They are for planting only in Pennsylvania.
3. Application should be made at least several months before the planting season, which begins about the first of April, and no application will be granted after the 31st of March.
4. Applications must be filled out in detail.
5. Notice as to whether or not the application can be granted will be given several weeks before trees are shipped.
6. Acknowledgment of receipt of nursery stock must be made promptly. For this, use Form 52, "Nursery Stock Receipt."
7. Remittance must accompany "Nursery Stock Receipt."
8. Seedlings must be planted without delay.
9. Make report to the Department of Forestry on the cost of the planting and the conditions under which the plantation was made. For this, use Form 34-B.
10. Be prepared to make report to the Department of Forestry on the condition of the plantation whenever requested to do so.
11. Fewer than 500 seedlings will not be furnished.

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